Relativistic Time Measurements and Other Experiments Require Going Beyond Einstein to the Yilmaz Theory of Gravity

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$$W = \frac{3GM^2}{5R}$$

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“Deputy-General Relativity”*
should now take command

*Professor John Wheeler’s name for the Yilmaz Theory, chosen to encourage its development and application

$$U_G = -\frac{3}{5}\frac{GM^2}{R}$$

(Theme of the speaker’s talk at the “Wheeler Fest” In Princeton, Feburary 2006)

Th

“My field equations are like a house with two wings: The left-hand side is made of fine marble, but the right-hand side of perishable wood.”

-- Albert Einstein

The Yilmaz formulation of relativistic gravity completes Einstein’s field equations, making the right-hand side also of fine marble.

SOME OF THE STRENGTHS OF THE YILMAZ THEORY

(FULFILLING EINSTEIN'S HOPES FOR GENERAL RELATIVITY)

N-Body interactive solutions, exact in the low velocity limit

Exact multimode gravitational wave solutions of arbitrary strength

Compatibility with quantum theory

These, and many others, follow from the introduction of a true

tensor for the gravitational field stress-energy instead

OUTLINE

1. The speaker's path to advocacy of the Yilmaz theory:

   THE NEED TO COMPREHEND EXPERIMENTAL OBSERVATIONS

2. Introduction to the Yilmaz Theory from the Principle of Equivalence

3. Some experiments requiring the Yilmaz Theory:

   Lunar Laser Ranging measurements showing that

   gravitational binding energy gravitates

   Proper Time measurements showing that clock rates are independent

   of latitude on the rotating Earth

   The measured isotropy of the local one-way speed of light on

OUTLINE (continued)

4. Mathematical structure comparisons between GR and the Yilmaz Theory:

   Consequences of the Freud decomposition and Identity

5. Some properties of the Yilmaz theory of importance for astrophysics:

   Compact objects exist without event horizons - No “Black Holes”

   Radiation can always escape into a narrow cone, extremely redshifted

   No singularities - the Kretschmann invariants are zero, not infinite

   Exact gravitatiional wave solutions exist transporting energy and

Key Postulate of Special Relativity

The speed of light is isotropic and has the value c

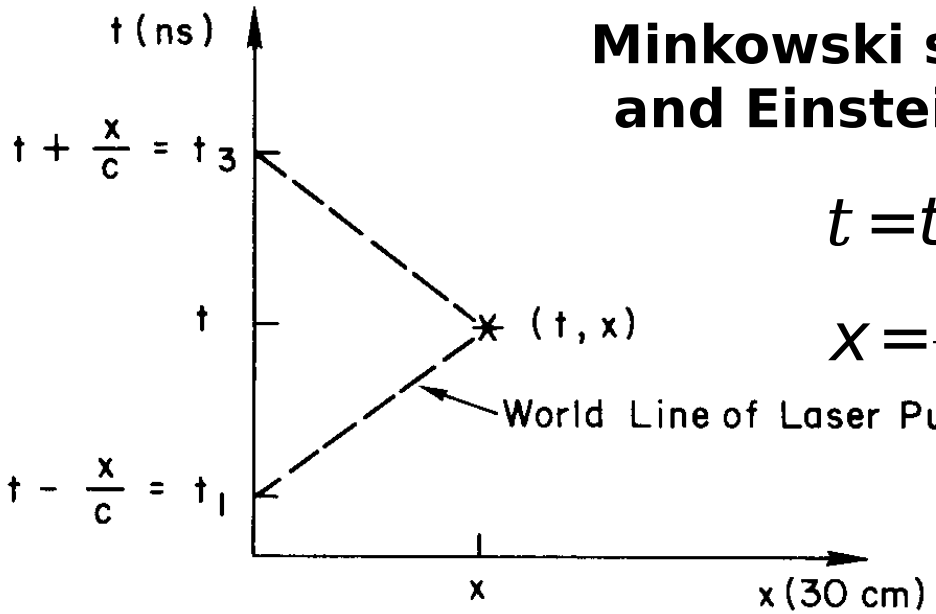
(c = 2.99792458 x 10^8 m/s)

whenever measured by an <u>INERTIAL OBSERVER</u>

This was given geometric expression with spacetime diagrams by the mathematician Herman Minkowski

[recall last talk of Einstein, Princeton, 1954]

The Yilmaz theory extends this property of the local speed of light to <u>ACCELERATED OBSERVERS</u> and to <u>OBSERVERS IN A GRAVITATIONAL FIELD</u>



Minkowski spacetime diagrams and Einstein time comparison

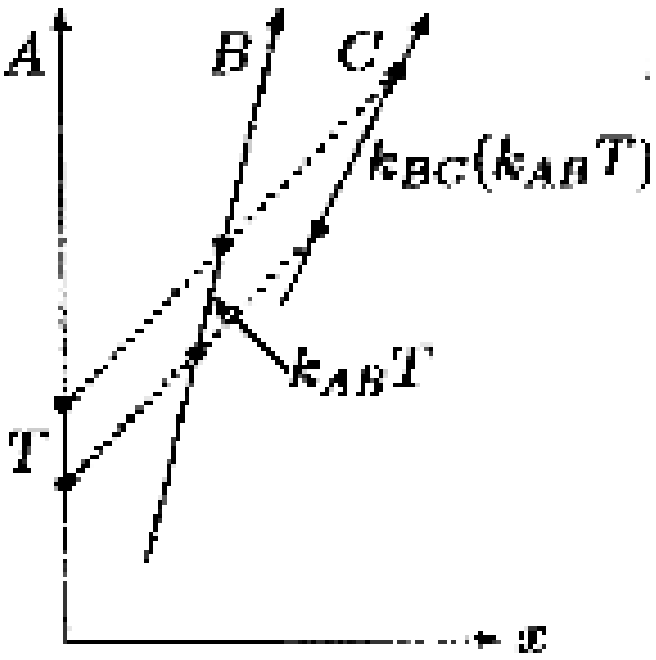
$$t = t_1 + \tfrac{1}{2}(t_3 - t_1) = \tfrac{1}{2}(t_1 + t_3)$$

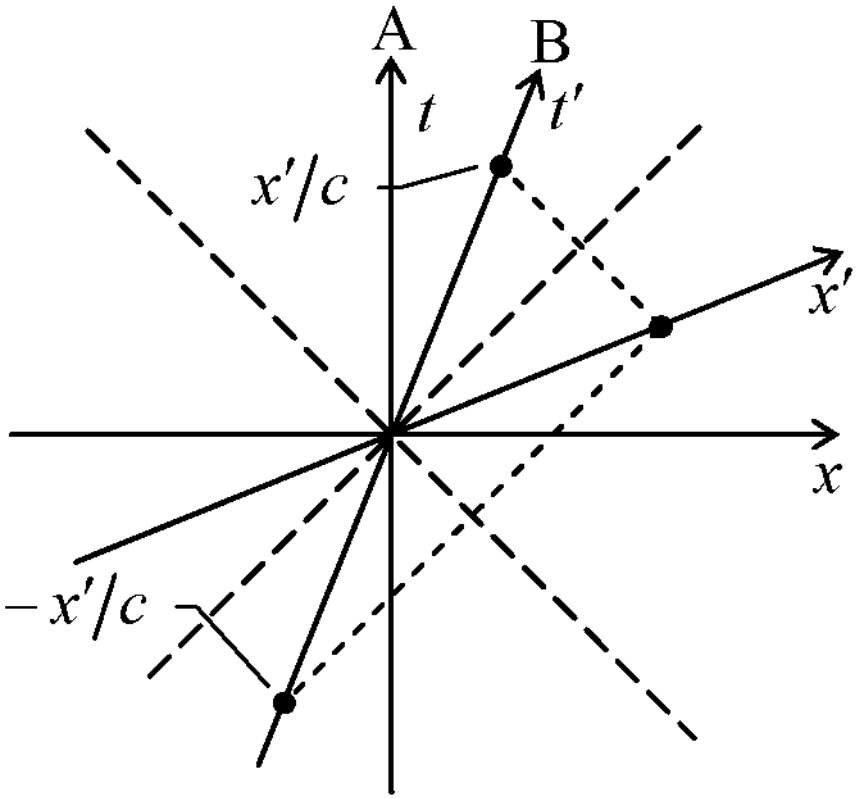
$$x = \tfrac{1}{2}(t_3 - t_1)c$$

Relativistic Doppler Factor, called k by Hermann Bondi in his "k-calculus"

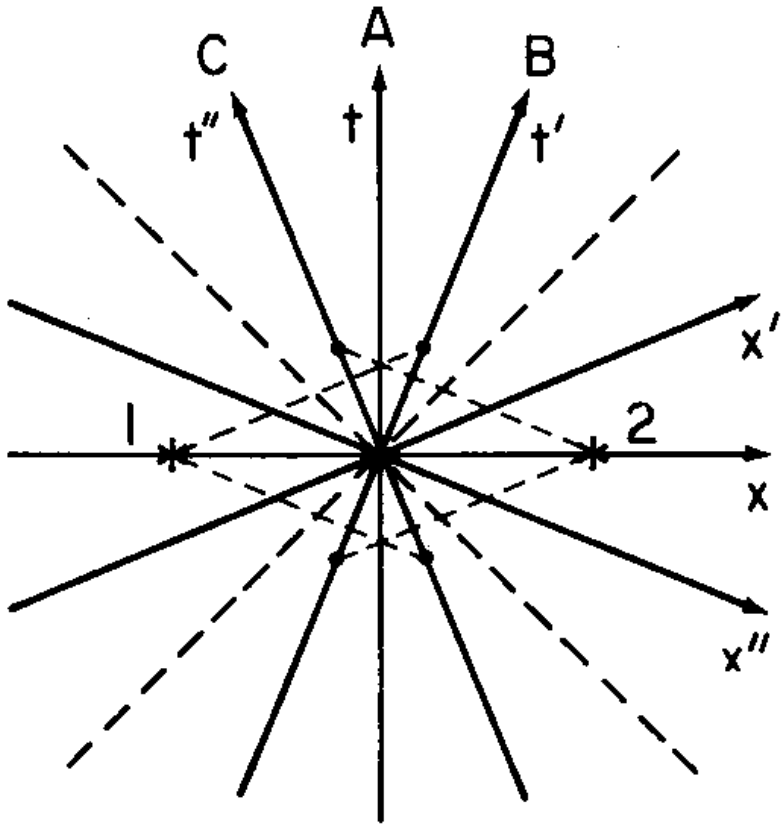
$$k = \frac{1+v/c}{\sqrt{1-v^2/c^2}} = \sqrt{\frac{1+v/c}{1-v/c}}$$

$$k_{AC} = k_{BC}k_{AB} = k_{AB}k_{BC}$$



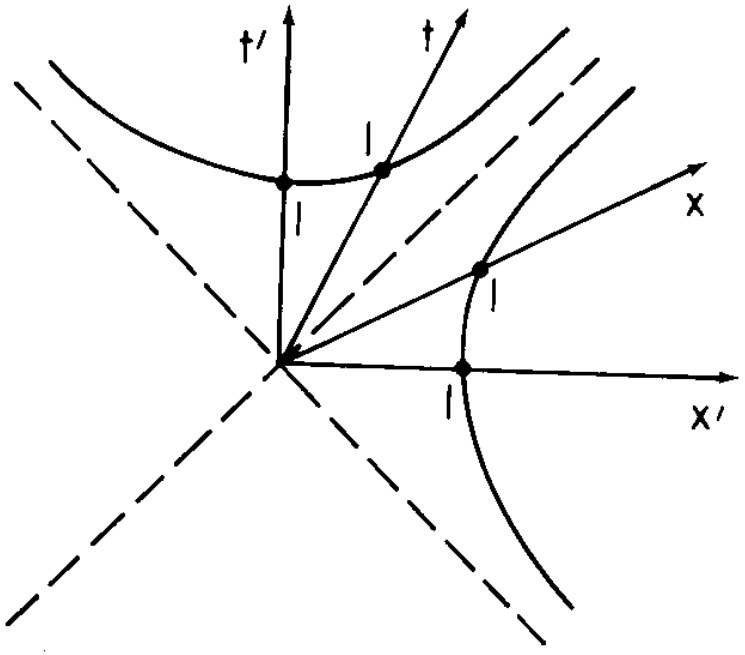


Establishment of an axis of multaneity using light pulses



“Slicing up” of spacetime (Minkowski, 1907)

Events 1 and 2 are simultaneous for observer A
for observer B: 2 occurs before 1
for observer C: 1 occurs before 2



Branches of the invariant Hyperbolas

$$c^2t'^2 - x'^2 = c^2t^2 - x^2$$

$$= \pm 1$$

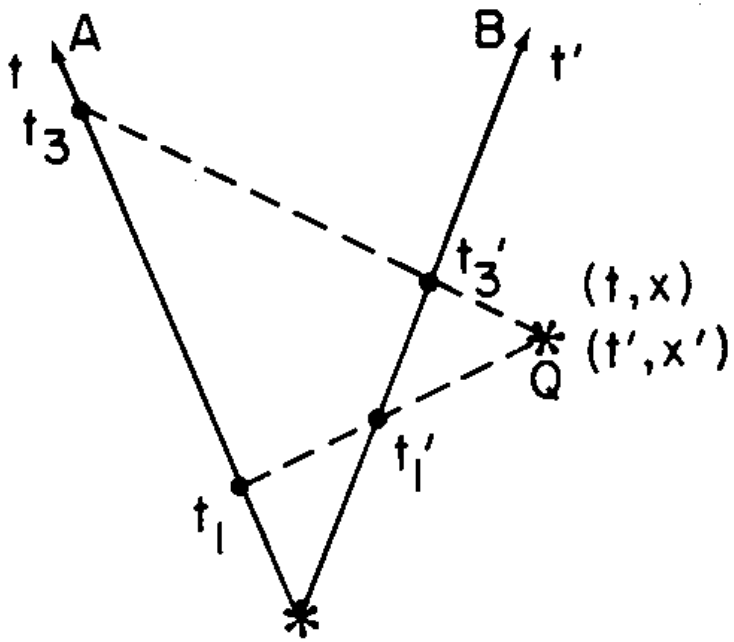


Diagram for proving the Invariance of the interval

$$t_1' = kt_1,\ t_3 = kt_3'$$

k-calculus derivation of the invariant interval

$$t'_1 = k t_1,\ t'_3 = \frac{1}{k} t_3$$

Multiply equations To derive Invariant interval

$$\boxed{\begin{aligned} t' - \frac{x'}{c} &= k\left(t - \frac{x}{c}\right) \\ t' + \frac{x'}{c} &= \frac{1}{k}\left(t + \frac{x}{c}\right) \end{aligned}}$$

add and subtract equations to derive Lorentz transformation

$$t'^2 - \frac{x'^2}{c^2} = t^2 - \frac{x^2}{c^2}$$

Invariant interval $c^2 t'^2 - x'^2 = c^2 t^2 - x^2 \equiv s^2$

Lorentz Transformations

The algebraic relations between the different coordinates
(t, x) and (t’, x’) assigned to the same event by the two different observers can be found by adding and subtracting the earlier pair of boxed equations:

$$t' = \frac{1}{2}\left(k + \frac{1}{k}\right)t - \frac{1}{2}\left(k - \frac{1}{k}\right)\frac{x}{c} = \frac{1}{\sqrt{1 - v^2/c^2}}\left(t - \frac{vx}{c^2}\right)$$

$$x' = \frac{1}{2}\left(k + \frac{1}{k}\right)x - \frac{c}{2}\left(k - \frac{1}{k}\right)t = \frac{1}{\sqrt{1 - v^2/c^2}}(x - vt)$$

Differential form of the Invariant Interval and the definition of Proper Time, a clock's own time (eigenzeit)

$$c^2 dt'^2 - dx'^2 = c^2 dt^2 - dx^2 = ds^2 \ (\text{"}metric\text{"})$$

$$dx' = 0, \qquad dt' \equiv d\tau \quad proper\ time\ increment$$

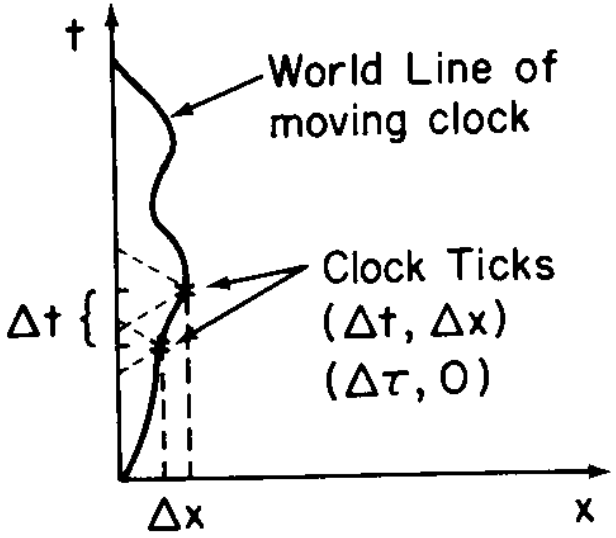
$$ds^2 = c^2 d\tau^2 = c^2 dt^2 - (dx^2 + dy^2 + dz^2)$$

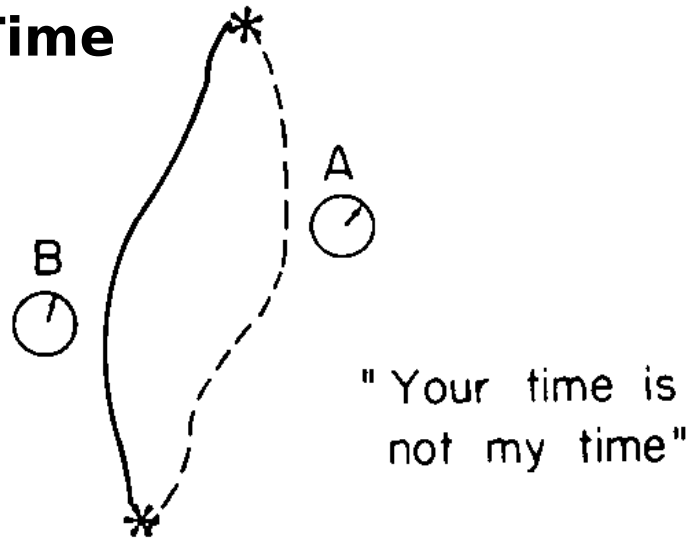
$$d\tau^2 = dt^2 - \frac{v^2 dt^2}{c^2} = (1 - v^2/c^2)\, dt^2$$

$$\boxed{d\tau = \sqrt{1 - v^2/c^2}\, dt}$$

Proper Time Increment **Coordinate Time Increme**

"Route Dependence of Proper Time



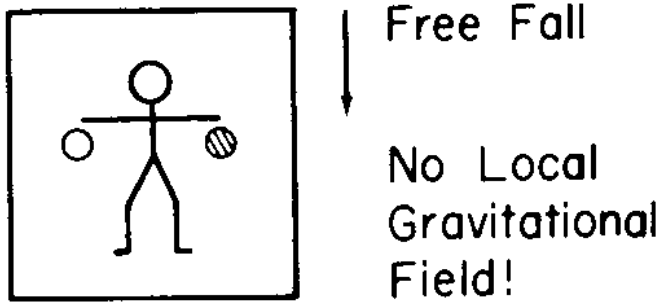


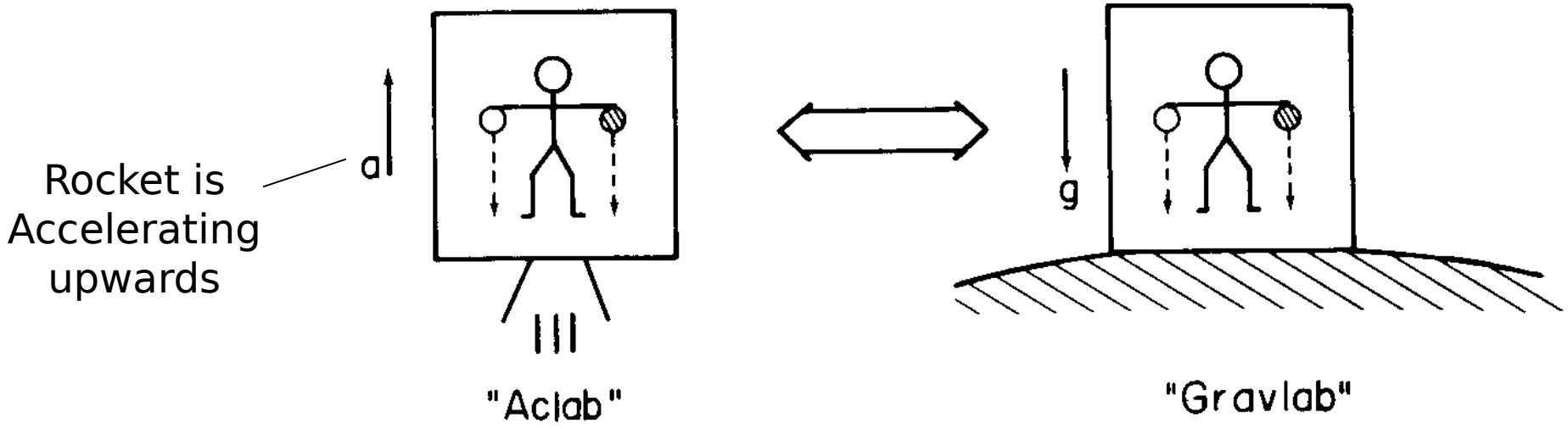
$$\tau_{A\,final} - \tau_{A\,initial} = \int_{initial}^{final} \sqrt{1 - v_A^{\,2}/c^2}\, dt$$

$$\tau_{B\,final} - \tau_{B\,initial} = \int_{initial}^{final} \sqrt{1 - v_B^{\,2}/c^2}\, dt$$

$$\tau_{A\,final} - \tau_{A\,initial} \neq \tau_{B\,final} - \tau_{B\,initial}$$

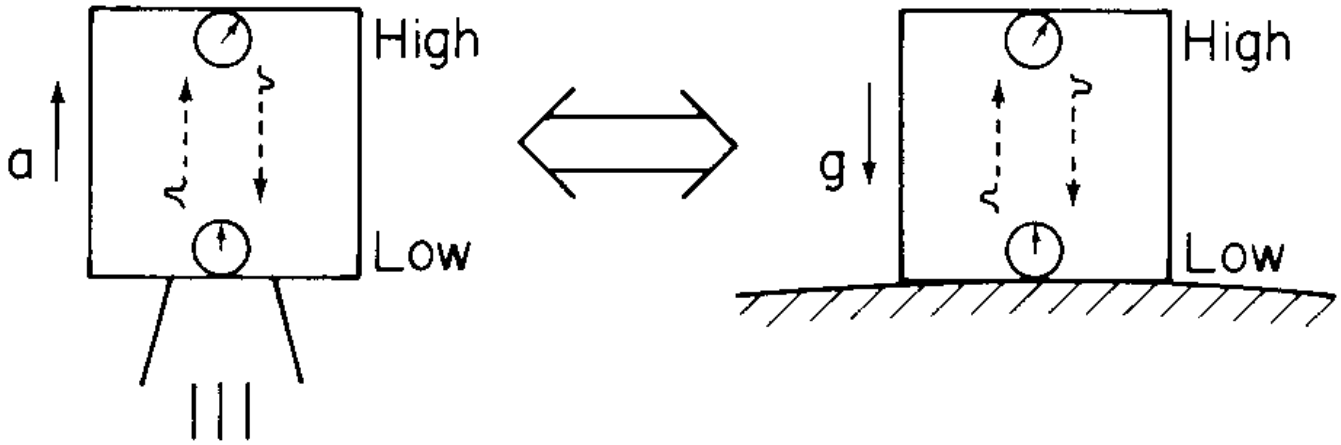
he elapsed proper time of an ideal clock **does not depend explicitly on its cceleration**, only on the above integrals. A real macroscopic physical clock will, f course, be affected by the stresses associated with its acceleration.



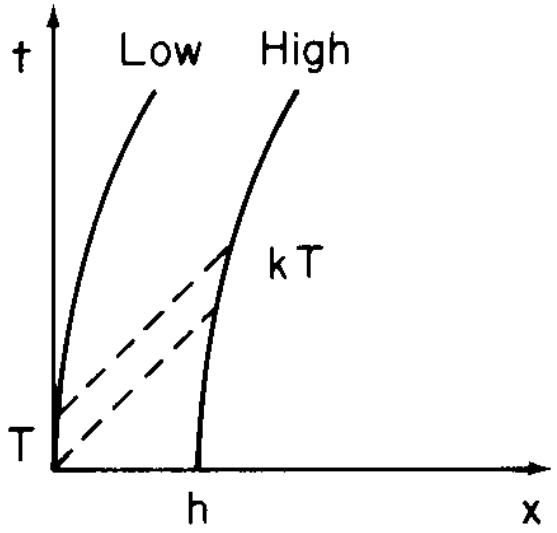


Principle of Equivalence

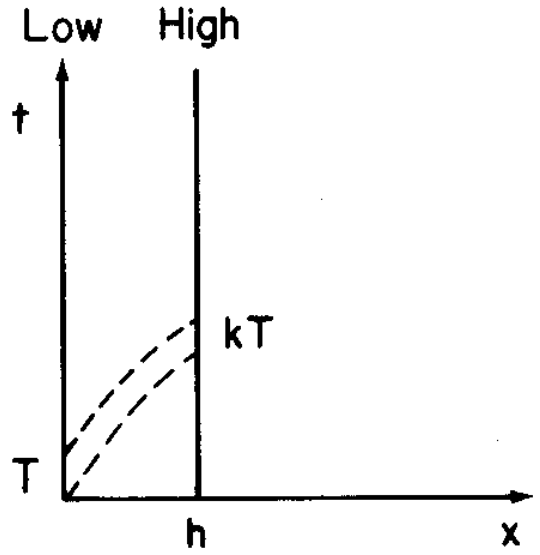
Introduction of gravity by the Principle of Equivalence



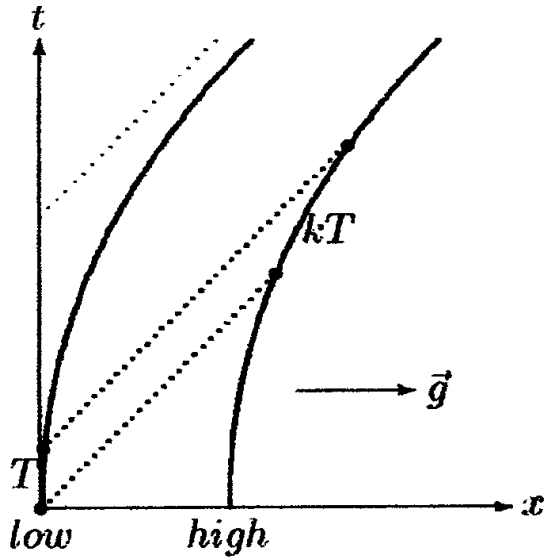
"Aclab"

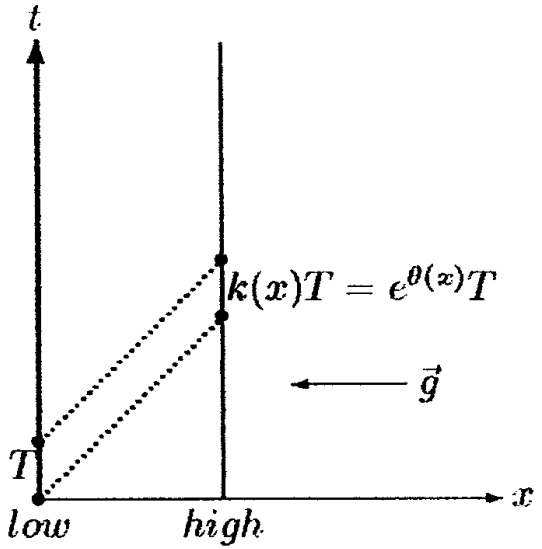


"Gravlab"



t Special Relativistic Implementation of the Principle of Equival





Introduce velocity parameter θ: $\frac{v}{c} = \tanh\theta$

$$k = \frac{1+\frac{v}{c}}{\sqrt{1-v^2/c^2}} = \frac{1+\tanh\theta}{\sqrt{1-(\tanh\theta)^2}} = \cosh\theta + \sinh\theta = e^{\theta}$$

$$k_{AC} = k_{AB}k_{BC} = e^{\theta_{AB}}e^{\theta_{BC}} = e^{\theta_{AB}+\theta_{BC}}$$

The Principle of Equivalence predicts that relative clock rates are affected by the Newtonian Gravitational Potential

Treat the acceleration of “Aclab” in a succession of comoving inertial frames of reference matching its increasing velocity. In each of these

$$\frac{dv}{c} = d(\tanh\theta) = \left.\frac{1}{(\cosh\theta)^2}\right|_{\theta=0} d\theta = d\theta$$

$$d\theta = \frac{dv}{c} = \frac{gdt}{c} = \left(\frac{g}{c}\right)\left(\frac{dx}{c}\right) = \frac{gdx}{c^2}$$

$$\theta(x) = \int_{low}^{high} d\theta = \frac{1}{c^2}\int_{low}^{high} gdx = \frac{\varphi(x)}{c^2}$$

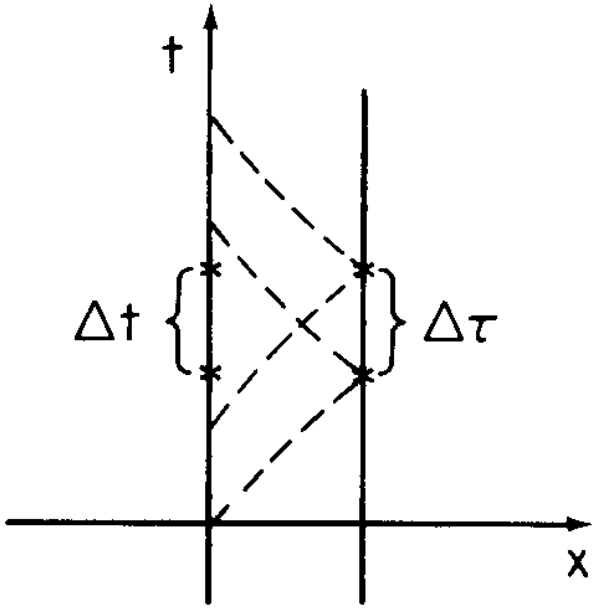
$\varphi(x)$ is the potential difference of the force field sensed in Aclab. This is to be identified with the Newtonion gravitational potential difference in Gravlab.

Clocks in a Gravitational Field

$$\Delta\tau \neq \Delta t$$

$$\Delta\tau = k(x)\Delta t = e^{\theta(x)}\Delta t$$

$$\Delta\tau = e^{\frac{\varphi(x)}{c^2}}\Delta t$$



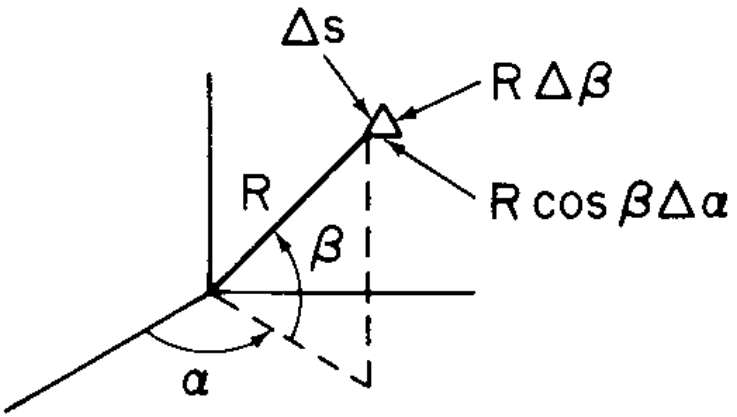
This result suggests generalizing the invariant interval of Minkowski from special relativity to curved spacetime

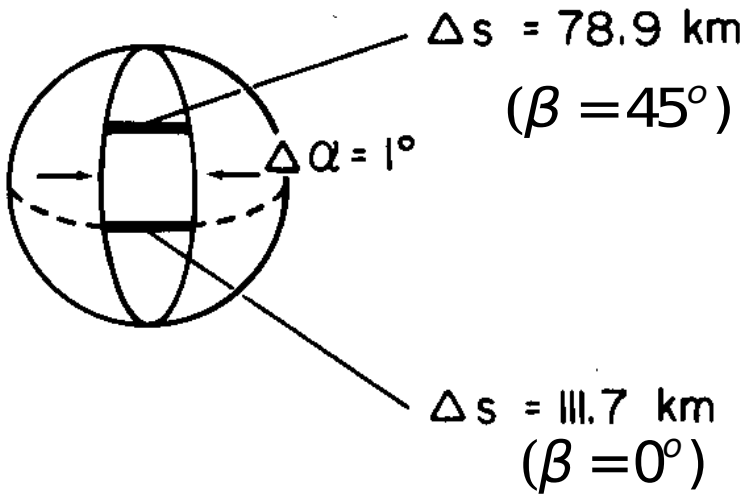
$$ds^2 = c^2 d\tau^2 = c^2 dt^2 - (dx^2 + dy^2 + dz^2)$$

$$\Rightarrow g_{00}c^2dt^2 + 2\sum_{i=1}^{3} g_{0i}\,c\,dt\,dx^i + \sum_{i,k=1}^{3} g_{ik}\,dx^i dx^k$$

For the clocks at rest (no spatial differentials)

$$ds^2 = c^2 d\tau^2 = k^2 c^2 dt^2 = e^{\frac{2\varphi(x)}{c^2}} c^2 dt^2, \qquad \boxed{g_{00} = e^{\frac{2\varphi(x)}{c^2}}}$$





Analogy of the relation between proper time and coordinate time
n curved spacetime to that between proper physical distance and the
coordinate difference of longitude on the curved spherical Earth

$$(\Delta s)^2 = R^2(\cos\beta)^2(\Delta\alpha)^2 + R^2(\Delta\beta)^2$$

Metric coefficients

he proper physical distance for one degree difference in
ngitude depends on the latitude

CURVED SPACETIME CHRONOMETRY

(J. L. Synge)

The use of Atomic Clocks and Laser Light Pulses in the examination of

gravitational fields may be compared to the use of

iron filings on paper over magnets and

horsehair cuttings on the surface of oil over charged electrodes

in the examination of magnetic and electric fields

(demonstrations by Michael Faraday in mid 19th century led him

Flying Atomic Clock Experiments carried out

during 1975-1977 by the Quantum Electronics Research Group

in the Department of Physics of the University of Maryland

in collaboration with

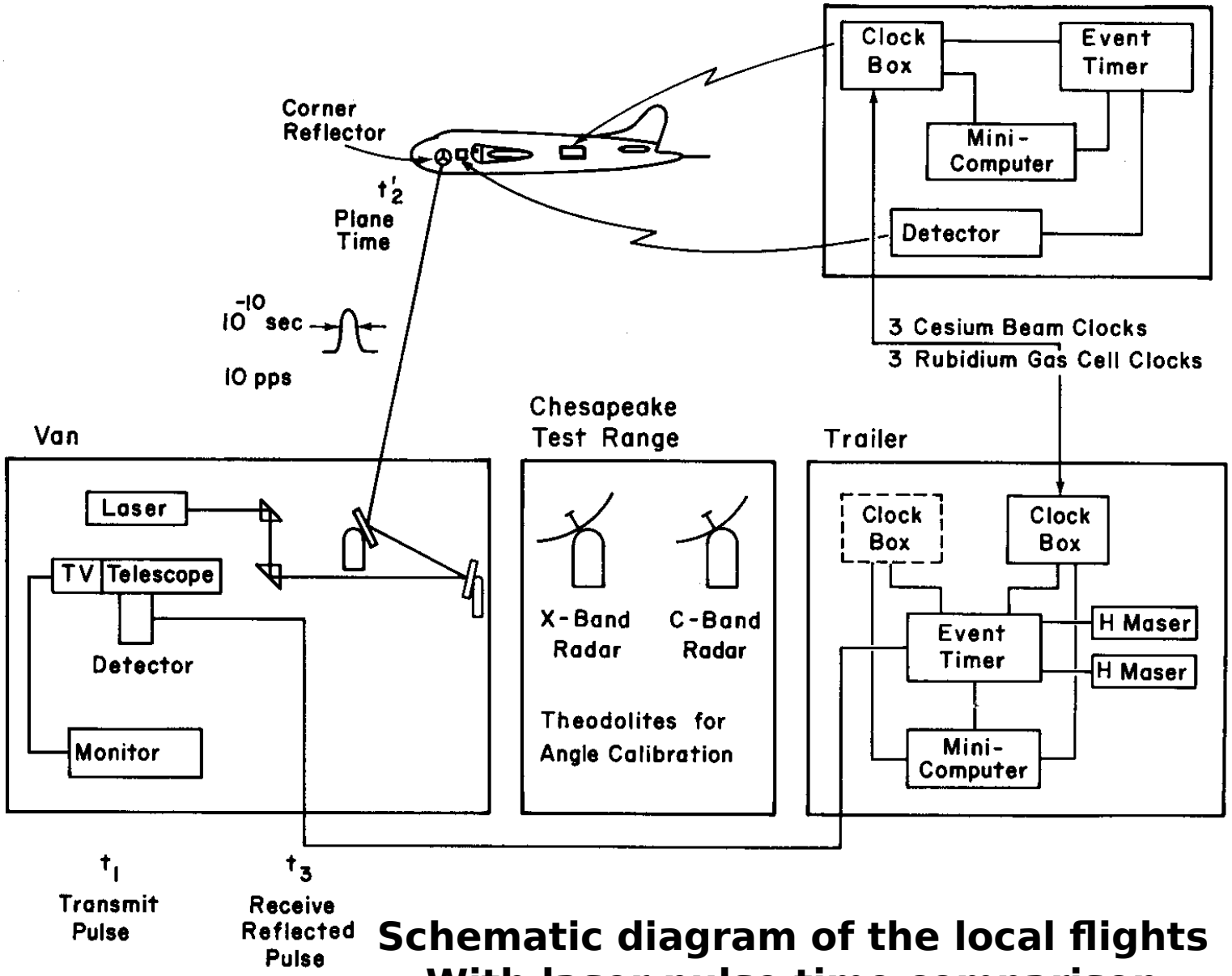
Leonard Cutler, Hewlett-Packard Company, chief designer of the cesium clocks

Gernot Winkler, U. S. Naval Observatory, Director of the Time Services Division

Ph. D. Theses:

Robert Reisse

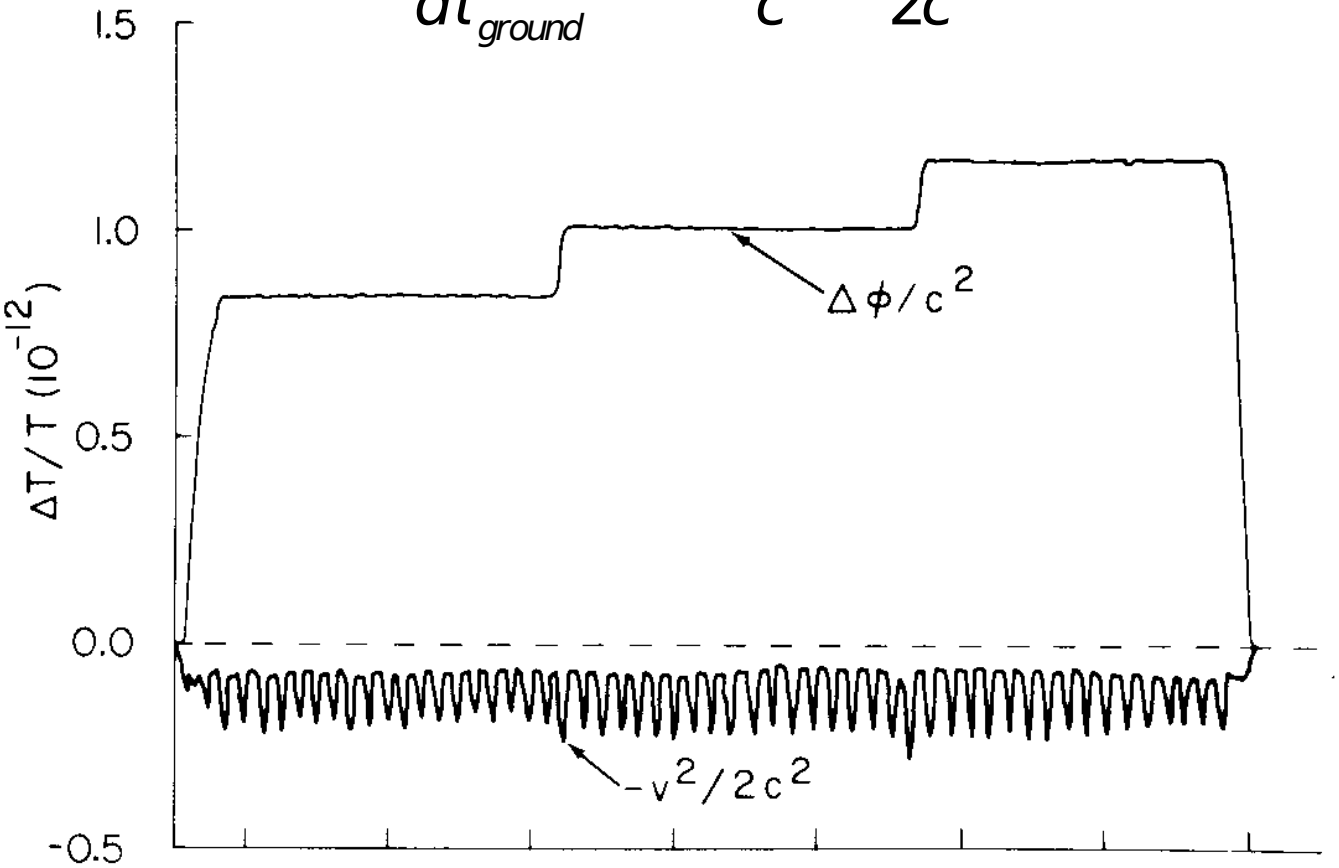
Ralph Williams



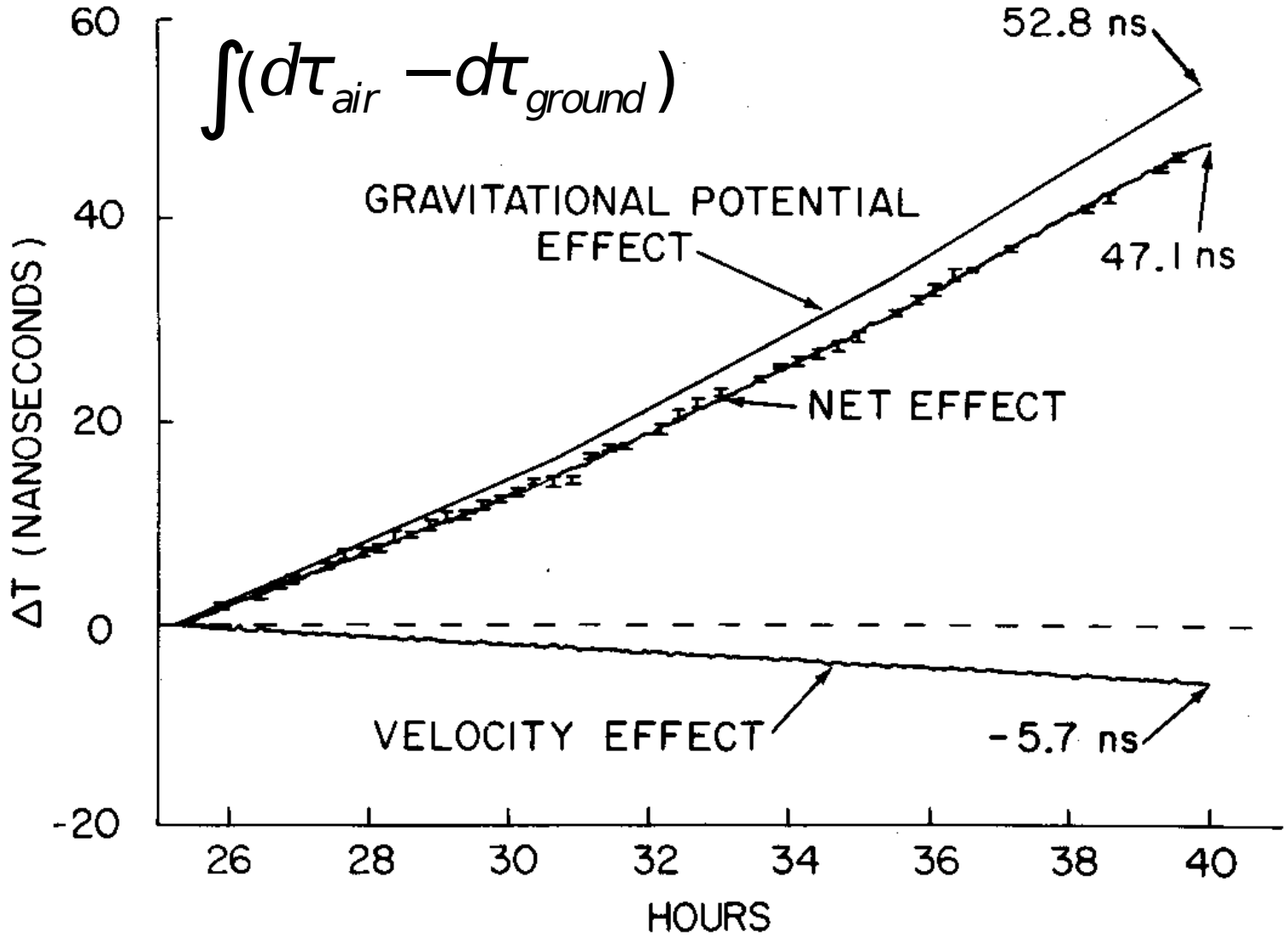
Schematic diagram of the local flights With laser pulse time comparison

$$ds^2 = c^2 d\tau^2 = e^{\frac{2\varphi}{c^2}} c^2 dt^2 - (dx^2 + dy^2 + dz^2) \approx \left(1 + \frac{2\varphi}{c^2}\right) c^2 dt^2 - v^2 dt^2$$

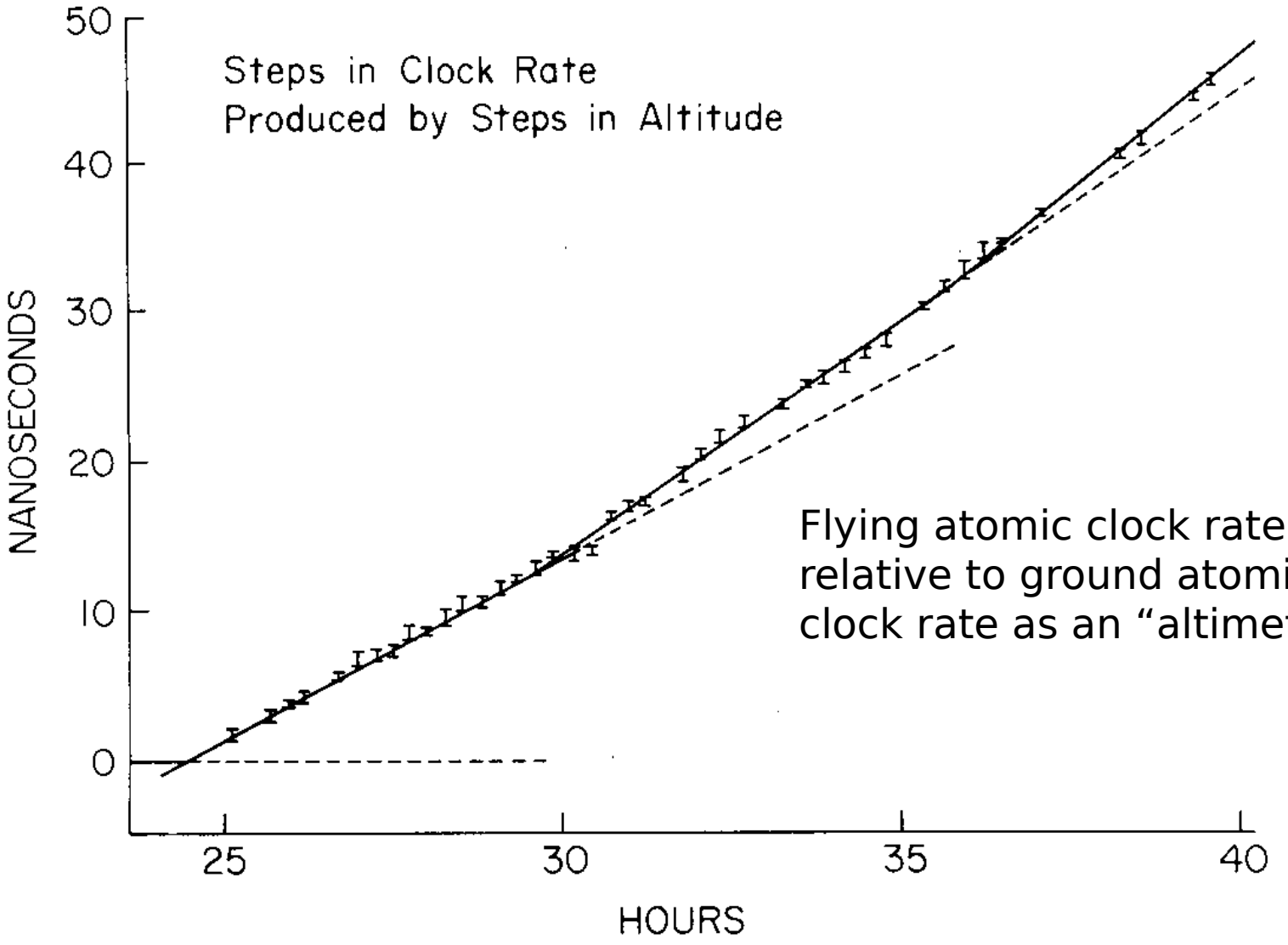
$$\Rightarrow \frac{d\tau_{air} - d\tau_{ground}}{d\tau_{ground}} \approx \frac{\Delta\varphi}{c^2} - \frac{v^2}{2c^2}$$



adar tracking data converted to the expected gravitational and velocity effects on time during the flight



Growth of the calculated proper time integrals during the flight a
Comparison of the predicted net effect with
the laser pulse time measurements



Flying atomic clock rate relative to ground atomic clock rate as an “altimeter”

How to determine the values of the spatial metric coefficients?

Physical conditions are imposed on the local speed of light:

that it propagate isotropically and have the local value c
Independent of the acceleration of the observer
and independent of the strength of the local gravitational field g = - gradient(φ).

These postulates of Yilmaz extend the key postulate

In curved spacetime the d'Alembertian wave operator is:

$$\Box^2\xi = \frac{1}{\sqrt{-g}}\partial_\alpha\left(\sqrt{-g}g^{\alpha\beta}\partial_\beta\xi\right) = g^{\alpha\beta}\partial_\alpha\partial_\beta\xi + \frac{1}{\sqrt{-g}}\underline{\partial_\alpha\left(\sqrt{-g}g^{\alpha\beta}\right)\partial_\beta\xi} = 0$$

$$g = \det(g_{\alpha\beta})$$

Setting the underlined expression = 0 is the <u>harmonic or DeDonder gauge condition</u>.

It eliminates the dependence on the gradient of the potential (the operand ξ can be considered as ϕ).

[It is also necessary for compatibility with quantum theory, allowing the wave group velocity to match the Hamiltonian particle velocity.]

Determination of the spatial metric coefficients

$$ds^2 = e^{\frac{2\varphi}{c^2}} c^2 dt^2 - (A^2 dx^2 + B^2 dy^2 + C^2 dz^2)$$

otropy requires A = B = C. We will also require in this limit that the metri
efficients not be explicit functions of time and use the gauge condition

$$ds^2 = e^{\frac{2\varphi}{c^2}} c^2 dt^2 - A^2 (dx^2 + dy^2 + dz^2)$$

$$\sqrt{-g} = e^{\frac{\varphi}{c^2}} A^3$$

$$\partial_\alpha (\sqrt{-g} g^{\alpha\beta}) = 0 \Rightarrow \partial_i \left(e^{\frac{\varphi}{c^2}} A^3 (A^{-2}) \right) = \partial_i \left(e^{\frac{\varphi}{c^2}} A \right) = 0$$

$$e^{\frac{\varphi}{c^2}} A = 1, \qquad A = e^{\frac{-\varphi}{c^2}}, \qquad \boxed{g_{ii} = -e^{\frac{-2\varphi}{c^2}}}$$

he exponential metric follows from compelling physic
Arguments, one of which has just been presented

$$ds^2 = c^2 d\tau^2 = e^{2\varphi} c^2 dt^2 - e^{-2\varphi}(dx^2 + dy^2 + dz^2)$$

e field equations are obtained by evaluating the Einstein-Hilber
rvature tensor for this metric.The gravitationsl field stress-energ
tensor appears added to the matter tensor

$$\frac{1}{2} G_\mu{}^\nu = \frac{4\pi G_N}{c^4}(\tau_\mu{}^\nu + t_\mu{}^\nu)$$

missing in general relativity

Einstein-Hilbert curvature tensor

stress-energy tensor of matter

stress-energy tensor of the gravitational field

general relativity the stress-energy of the gravitation field is explicitly excluded as a source of spacetime curvature. It is explicitly included as a source in the Yilmaz theory: "gravity gravitates"

**e gravitational field stress-energy tensor in this low velocity cas
the standard expression for a scalar field:**

$$t_{\mu}{}^{\nu} = -\partial_{\mu}\varphi\partial^{\nu}\varphi + \tfrac{1}{2}\delta_{\mu}{}^{\nu}\partial_{\lambda}\varphi\partial^{\lambda}\varphi$$

**The absence of this quantity in general relativity is responsible
for the lack of interactive N-body solutions among massive bodi
n that theory.**

In the static or low velocity case which has been treated so far e quantity ϕ is the Newtonian many-body gravitational potentia

$$\varphi(\mathrm{r}x) = \sum_A \frac{G_N m_A}{\left|\mathrm{r}x - \mathrm{r}x_A\right|} + C$$

The constant C can be chosen to make ϕ = 0 at the position of the observer giving the Minkowski valued metric (1, -1, -1, -1) of special relativity.

The velocity of light has the value c locally.

$$ds^2 = g_{\mu\nu} dx_\mu dx^\nu = e^{2\varphi} c^2 dt^2 - e^{-2\varphi}(dx^2 + dy^2 + dz^2)$$

$$\Big|_{\varphi=0} \mapsto c^2 dt^2 - (dx^2 + dy^2 + dz^2) = 0 \quad for\ light$$

ere is no need to transform to the Riemannian norma dinate system where the first derivatives on the metr efficients vanish to achieve the local Minkowski values

In the general case all known exact solutions have metric coefficients which are exponential functionals of a gauge field

$$g_{\mu\nu} = \left(\eta e^{4\left(\hat{\varphi} - \frac{1}{2}\varphi \hat{1}\right)}\right)_{\mu\nu}$$

where η *is the Minkowski metric*

$$\varphi_\mu{}^\nu = \hat{\varphi} = \begin{pmatrix} \varphi_0{}^0 & \varphi_0{}^1 & \varphi_0{}^2 & \varphi_0{}^3 \\ \varphi_1{}^0 & \varphi_1{}^1 & \varphi_1{}^2 & \varphi_1{}^3 \\ \varphi_2{}^0 & \varphi_2{}^1 & \varphi_2{}^2 & \varphi_2{}^3 \\ \varphi_3{}^0 & \varphi_3{}^1 & \varphi_3{}^2 & \varphi_3{}^3 \end{pmatrix}$$

$$\varphi = tr\hat{\varphi}$$

nder a gauge condition similar to the Feynman gauge of electrodynamic
gauge potential is a solution of the curved spacetime d'Alembert equat

$$\boxed{\nabla^2 \varphi_\mu{}^\nu = \tau_\mu{}^\nu} \Rightarrow \sigma u_\mu u^\nu \;\Big|_{\frac{v}{c} \to 0} \mapsto \nabla^2 \varphi_{33} = -\sigma$$

Important exact solutions in the general case are those for transverse-traceless plane gravity waves of arbitrary strength

$$\hat{\varphi} = \begin{pmatrix} . & . & . & . \\ . & \varphi_1^{\,1} & \varphi_1^{\,2} & . \\ . & \varphi_2^{\,1} & \varphi_2^{\,2} & . \\ . & . & . & . \end{pmatrix}$$

$$\boxed{\varphi_1^{\,1} = -\varphi_2^{\,2} = \tfrac{1}{2}\sum h_+(t,z)}$$

$$\boxed{\varphi_1^{\,2} = \varphi_2^{\,1} = \tfrac{1}{2}\sum h_\times(t,z)}$$

$$\boxed{-g_{11} = e^{2\sum h_+(t,z)} \qquad -g_{22} = e^{-2\sum h_+(t,z)}}$$

$$\boxed{-g_{11} = -g_{22} = \cosh 2\sum h_\times(t,z) \qquad -g_{12} = -g_{21} = \sinh 2\sum h_\times(t,z)}$$

se are exact multimode solutions which carry energy and momen
and there is an analog of the Poynting theorem for EM waves.
Solutions with such properties do not exist in general relativity

equires the weak field approximation and cannot handle strong

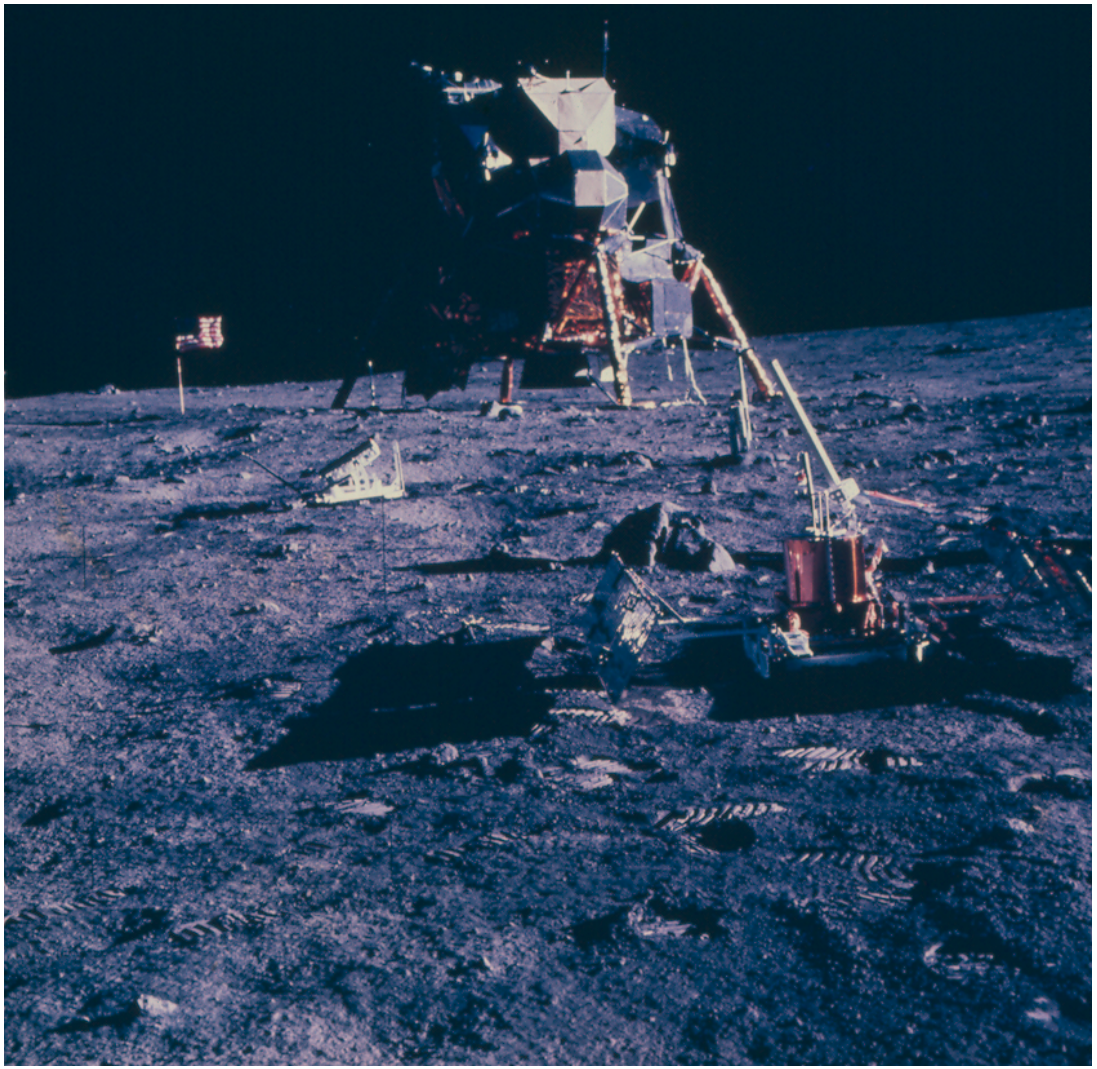
$$g_{\mu\nu} \approx \eta_{\mu\nu} + h_{\mu\nu} + \text{higher order terms} \qquad \left|h_{\mu\nu}\right| = 1$$

GAUGE FIELD THEORY ANALOGIES

A^ν	$\phi_\mu{}^\nu$
$j^\nu = \Box^2 A^\nu - \partial_\alpha(\sqrt{-g}\,\partial^\nu A^\alpha)/(\sqrt{-g})$	$\tau_\mu{}^\nu = \Box^2 \phi_\mu{}^\nu - \partial_\alpha(\sqrt{-g}\,\partial^\nu \phi_\mu{}^\alpha)/(\sqrt{-g})$
$\partial_\nu(\sqrt{-g}\, j^\nu) \equiv 0$	$\partial_\nu(\sqrt{-g}\, \tau_\mu{}^\nu) \equiv 0$
$\partial_\nu A^\nu = 0$	$\partial_\nu \phi_\mu{}^\nu = 0$
$j^\nu \Rightarrow \rho u^\nu$	$\tau_\mu{}^\nu \Rightarrow \sigma u_\mu u^\nu$

$$\tau_\mu{}^\nu = \Box^2 \phi_\mu{}^\nu - (1 - \zeta)\partial_\alpha(\sqrt{-g}\,\partial^\nu \phi_\mu{}^\alpha)/(\sqrt{-g})$$

Laser Ranging to Retro-Reflectors on the Moon



- **The Most Significant Physics Results of nearly 37 years of**
- **continuous Lunar Laser Ranging are the following:**

  - **The massive bodies Earth and Moon fall to the Sun with the same acceleration. That is, gravitational binding energy gravitates like the mass equivalent of other energy**

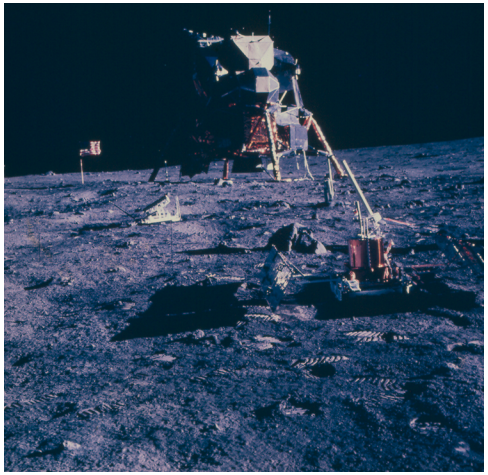
    “Strong Principle of Equivalence”

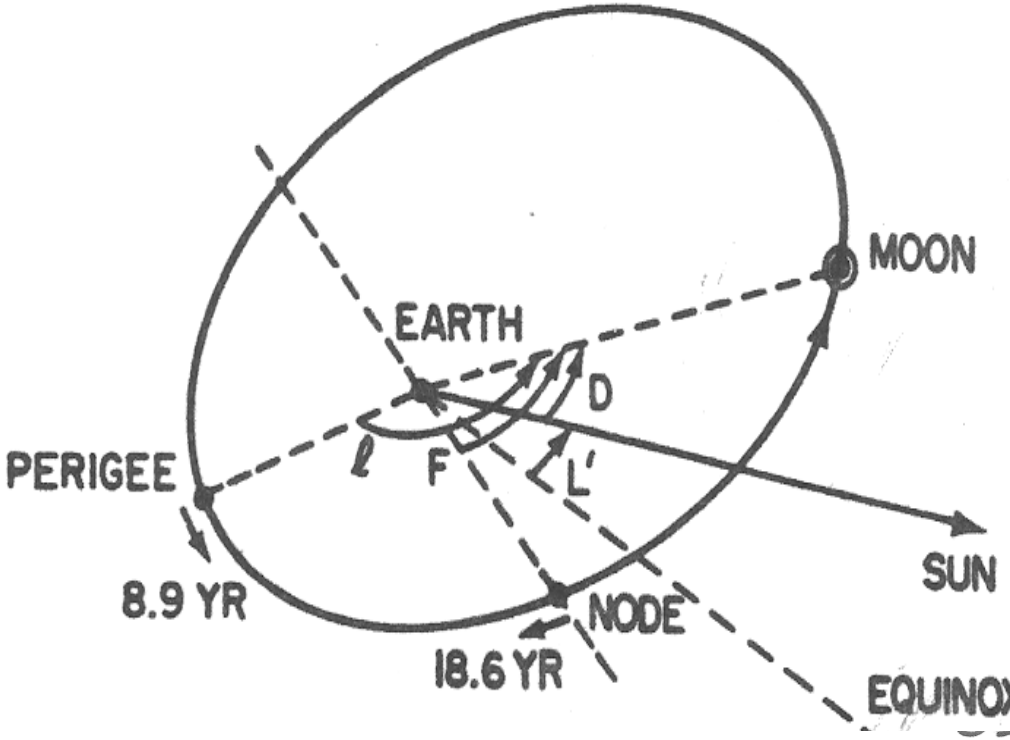
    “Gravity gravitates”

  - **The Brans-Dicke Scalar-Tensor Theory fails since it predicts different accelerations for the Earth and the Moon toward the Sun**

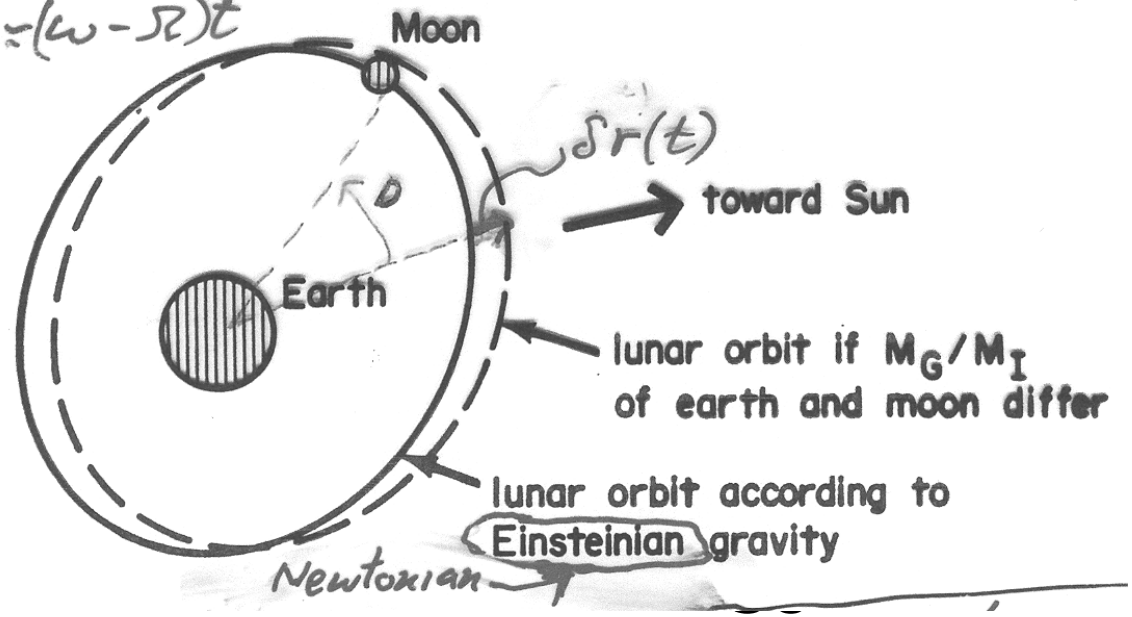
  - **General Relativity can not account for the measurements since it lacks both N-Body interactive solutions and the localization of gravitational field energy needed to calculate binding energy**

  - **The gravitational theory of Yilmaz is required to describe the measurements**





$D = (\omega - \Omega)t$



In Newtonian theory the gravitational binding energy of a spherically symmetric solid body can be found by calculating the work needed to pull the body apart, spherical shell by spherical shell, and taking the parts to an infinite distance

One finds

$$U_G = -\frac{3}{5}\frac{G_N M^2}{R}$$

The ratio of the fractional binding energies , Earth to Moon, is

$$\frac{\left(\frac{U_G}{Mc^2}\right)_{Earth}}{\left(\frac{U_G}{Mc^2}\right)_{Moon}} = \frac{-4.18\times10^{-10}}{-1.95\times10^{-11}} = 21.4$$

In the Brans-Dicke theory the value of G_N is a field quantity and depends on the distance of Earth and Moon from the Sun.

They would fall to the Sun with different

Relation between gravitational binding energy and the $t_0^{\ 0}$ component of the gravitational field stress energy tensor

$$t_0^{\ 0} = -\frac{1}{8\pi}(\nabla\phi)^2$$

$$U_G = \int_0^R t_0^{\ 0} dv + \int_R^\infty t_0^{\ 0} dv = -\frac{1}{10}\frac{GM^2}{R} - \frac{1}{2}\frac{GM^2}{R}$$

$$= -\frac{3}{5}\frac{GM^2}{R}$$

alculation cannot be done in general relativity becaus
Is no localizible gravitational stress-energy tensor

5 Parameterizing Gravity Theories

The parametric PPN method originated with A. S. Eddington, H. P. Robertson and others. The idea is to expand the metric into potentials with certain parameters and codify the theories with the parameter values to which it leads. Since observed effects correspond to certain values of these parameters, one can quickly judge a theory by simply looking at its parameter values instead of calculating the observed effects for each theory anew from scratch. For example, let

$$g_{00} = 1 - 2\alpha\phi + 2\beta\phi^2 \tag{5.1}$$

$$-g_{0i} = 4\phi_{0i} \tag{5.2}$$

$$-g_{ik} = \delta_{ik}(1 + 2\gamma\phi + 2\delta\phi^2) \tag{5.3}$$

The general relativity theorists who analyze the lunar laser ranging data assume that ϕ is the many body Newtonian potential. However this requires the Yilmaz theory!

In order for the theory to be viable one must have:

Gravitational frequency shift:	$\alpha = 1$
Gravitational light deflection:	$\alpha + \gamma = 2$
Relativistic perihelion shift:	$2\alpha(\alpha + \gamma) - \beta = 3$
Planetary-perturbative shift:	$\lambda = \delta = 1$

As to viability $\alpha = \beta = \gamma = \delta = 1$ we then have the partial list:

Table II
PPN Parameters

Theory	α	β	γ	δ	SEP	ϕ
Einstein:	1	1	1	$\frac{3}{4}$	No	$\frac{m}{r}$
Brans-Dicke:	1	1	$\frac{\omega+1}{\omega+2}$	$\frac{3}{4}$	No	$\frac{m}{r}$
Yilmaz:	1	1	1	1	Yes	$\sum_A \frac{m_A}{r_A} + C$

where $\lambda = 4\delta - 3$

Harmonic Gauge

$\partial_\nu(\sqrt{-g}g^{\mu\nu}) = 0$

$\Rightarrow \delta = 2\alpha\gamma - \beta = 1$

Note N-body potential for the Yilmaz theory!

Comment on the “Nordtvedt Effect”

Nordtvedt studied in the context of the PPN formalism whether the gravitational binding energy could affect the gravitational mass

$$M_G = M\left(1+\eta\frac{U_G}{Mc^2}\right)$$

Laborious calculations give

$$\eta = 4\beta - \gamma - 3$$

which vanishes for the general relativity values $\beta = \gamma = 1$

Yilmaz theory addresses the issue very simply since the equations of motion include the field stress-energy tensor

$$\frac{dp_\mu}{d\tau} = \tfrac{1}{2}\partial_\mu g_{\alpha\beta}(\tau^{\alpha\beta} + t^{\alpha\beta}) \equiv \frac{1}{\sqrt{-g}}\partial_\nu(\sqrt{-g}\,t_\mu{}^\nu)$$

he exponential metric of the low-velocity limit, one fin

$$\frac{dp_k}{d\tau} = \sigma\,\partial_k\varphi + \partial_k\varphi(t_0{}^0 - t_i^{\,i}) = \partial_k\varphi\,\sigma\left[1 + \frac{t_0{}^0}{\sigma}\left(\frac{t_0{}^0 - t_i^{\,i}}{t_0{}^0}\right)\right]$$

rms of densities, the corresponding Nordtvedt parame

$$\eta = \frac{t_0{}^0 - t_i^{\,i}}{t_0{}^0}$$

Explicit evaluation yields

$$(t_0{}^0 - t_i^{\,i}) = (\tfrac{1}{2}(\nabla\varphi)^2 - \tfrac{1}{2}(\nabla\varphi)^2) = 0$$

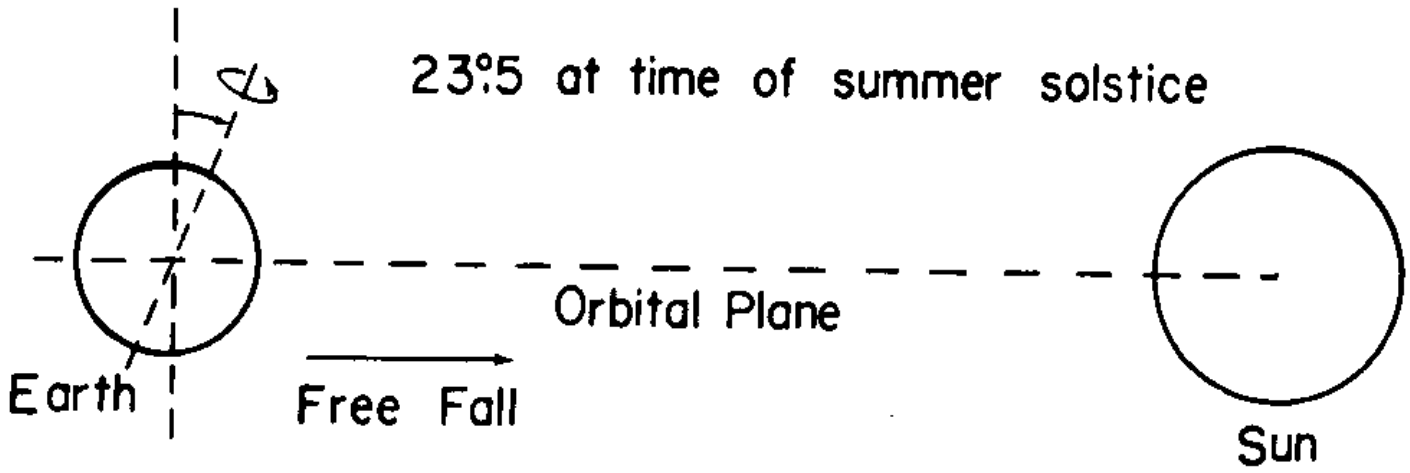
s no anomalous influence of the gravitationalbinding e

“Gravity gravitates” like other forms of energy

Global Clock Transport Flights summer solstice 1977

Air Force C-141 and the “Two-Ton Timex”

The Earth as an elevator falling toward the Sun



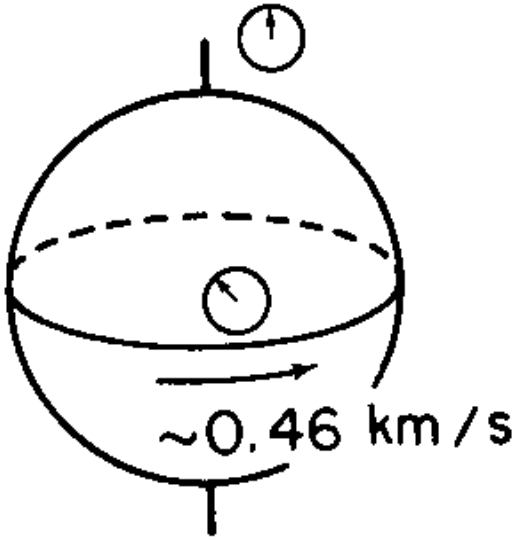
“Floor” = Northern Hemisphere: Washington, USA (low clock)
“Ceiling” = Southern Hemisphere: Christchurch, NZ (high clock

oes the “Ceiling Clock” run fast with respect to the“Floor Clock”
cause of the difference in the Sun’s gravitational potential?

Before the clock flights and measurements were carried out in 1997,
no clear answer could be obtained from the general relativity community.

The experimental answer is NO, to first order.
The explanation lies in the Principle of Equivalence

Clocks on the rotating Earth



Einstein's "mistake" in his 1905 paper on special relativity

He stated that a clock at the equator would run slow with respect to one at the pole because of its velocity

In fact, the change in gravitational potential from the equator to the pole on the oblate Earth just compensates the change in velocity. (equatorial radius - polar radius = 21 km)

Identical clocks on the geoid run at the same rate, independent of the latitude.

The effect of gravitational potential on clocks was discovered by Einstein only in 1907!

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ARTICLES

A Small Puzzle from 1905

In his first relativity paper, Einstein made one erroneous prediction. Althou withdrawn when he generalized the theory to include gravity, the original surprisingly little attention.

Alex Harvey and Engelbert Schucking

The best known of the paradigm-shattering papers published by Albert Einstein in 1905 his annus mirabilis, is the one titled "On the Electrodynamics of Moving Bodies."[1] It wa there that the principle of special relativity was set forth. Einstein asserted in this pape that time is relative. That is, if two inertial observers in uniform motion at relative velocity v were equipped with identical clocks, each would judge the other's clock to be running too slowly by a factor $v^2/2c^2$ (excluding higher-order terms).

Einstein immediately applied that result to a pair of identical clocks, one located on the equator and the other at either of the poles. Because of Earth's rotation relative to an almost inertial reference frame, a clock fixed at a point on the equator moves with a speed $v = 0.5$ km/s while a clock at the pole is essentially at rest. Thus, Einstein concluded in this first relativity paper, the equatorial clock is slower than the polar cloc

xperimental Results from the Clock Transport to Thul

nstein 1905 Prediction (ECI Coordinate Time):

$$d\tau/dt = \sqrt{1 - v^2/c^2} \approx 1 - v^2/2c^2$$

drews: Latitude 38.82 degrees
velocity = 360 meters/s

$$d\tau/dt - 1 = -7.2 \times 10^{-13}$$
$$= -61.7\,ns/day$$

ule: Latitude 76.53 degrees
velocity = 110 meters/s

$$d\tau/dt - 1 = -6.7 \times 10^{-14}$$
$$= -5.5\,ns/day$$

ule Clocks - Andrews Clocks:
[-5.5 - (-61.7)] ns/day = 56.2 ns/day 4 days → 224.8 ns

xperimental Measurement:

ule Clocks - Andrews Clocks after trip = 38 ± 5 ns
lculated Effect of transport and dwell time = 35 ± 2 ns

Prediction of Einstein in 1905 is clearly wrong!

hange of Gravitational Potential on the oblate Earth from the eq
pole compensates for the change in rotational velocity

ombination

$$\varphi - \frac{v^2}{2} = geopotential = const.$$

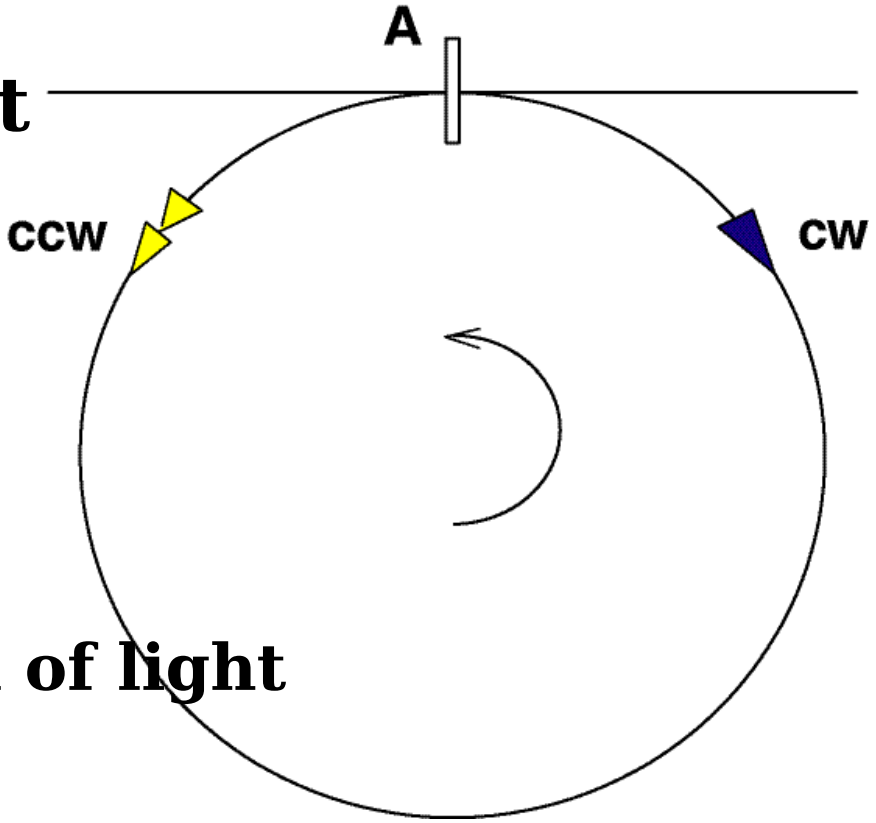
where ϕ is the multimode Newtonian gravitational potential and
v is the surface velocity of the rotating Earth. The geopotential i
stant along the geoid, which roughly coincides with mean sea le

Such exact multimode solutions are not available in general
elativity because of the absence of N-body interactive solutions
They are available exactly in the Yilmaz theory.

Including the monopole and quadrupole terms, where R is the
quatorial radius of the oblate Earth and β is the geocentric latitu

$$\varphi = -\int \frac{Gdm}{r'} = -\frac{GM}{r}\left[1 + \tfrac{1}{2}J_2\left(\frac{R}{r}\right)^2 (1 - 3\sin^2\beta)\right]$$

One-way Speed of Light in a Rotating Frame



Let r = radius

ω = angular velocity

The locally measured speed of light in the rotating frame

$\pm c$ or $r\omega \pm c$?

Most treatments of the ring laser gyroscope use $r\omega \pm c$.

For $r \rightarrow$ large, $r\omega$ = constant, this is inconsistent with special relativity.

Yilmaz predicted $\pm c$ in his Boston Studies in the Philosophy of Science lecture of 1969 and

There is great confusion in the literature about the Sagnac Effect

M. G. Sagnac, *Comptes Rendu, Acac. Sci.* 157 209 **(**1913)

For example the paper

The Sagnac Effect: Correct and Incorrect Explanations
By G. B. Malykin
***Physics-Uspekhi* 43 (**12) 1229-1252 (2000)

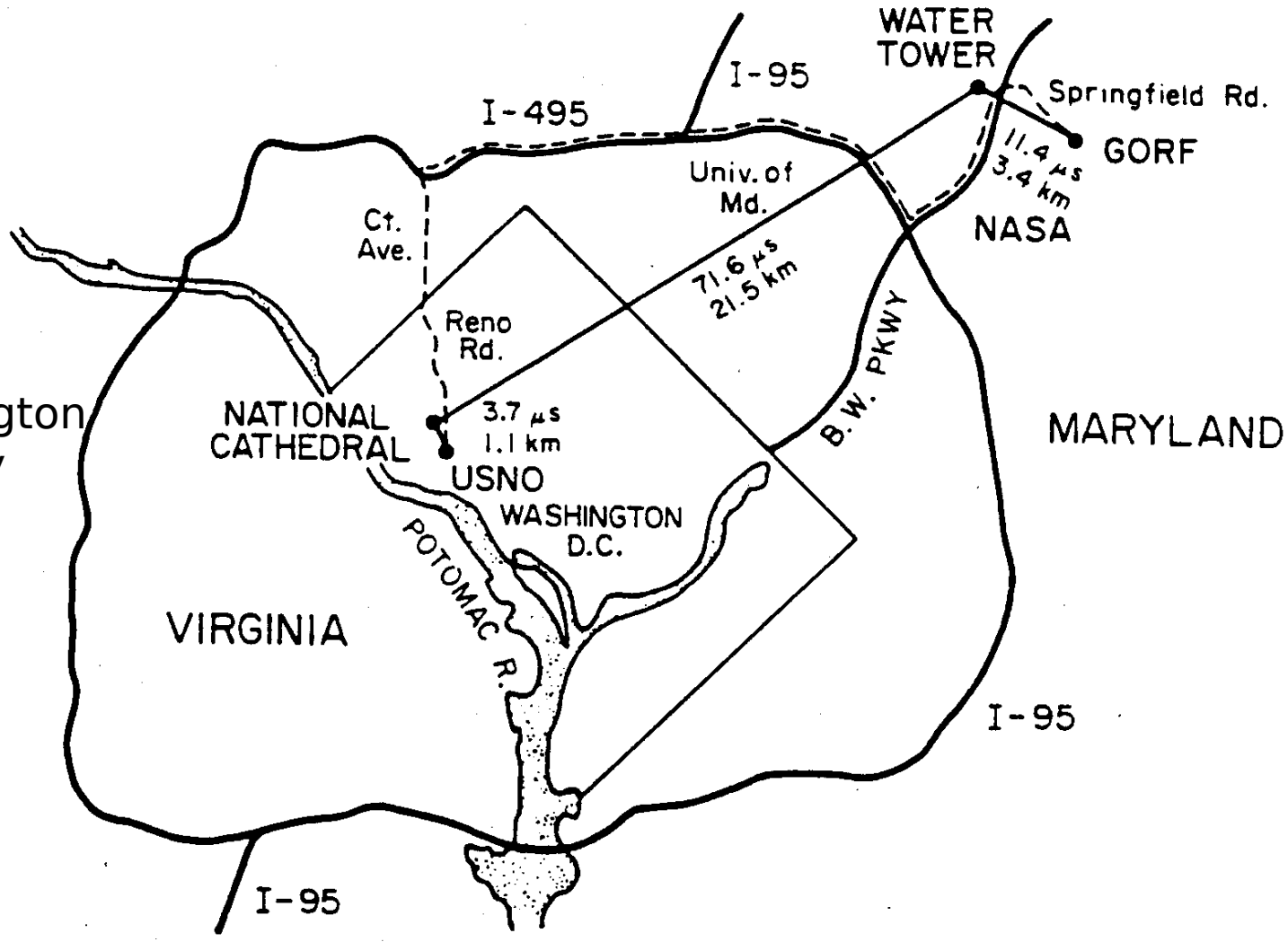
Contains 290 references to published papers!

The speaker renewed his study of the Yilmaz theory around 1981
when he was perplexed whether to use ± c or rω ± c in the last leg of the planned LASSO (Laser Synchronization from

Sstationary Orbit), an ESA/French experiment

way speed of light experiment carried out by the Quantum Electronics G
the Department of Physics on the University of Maryland at College Pa

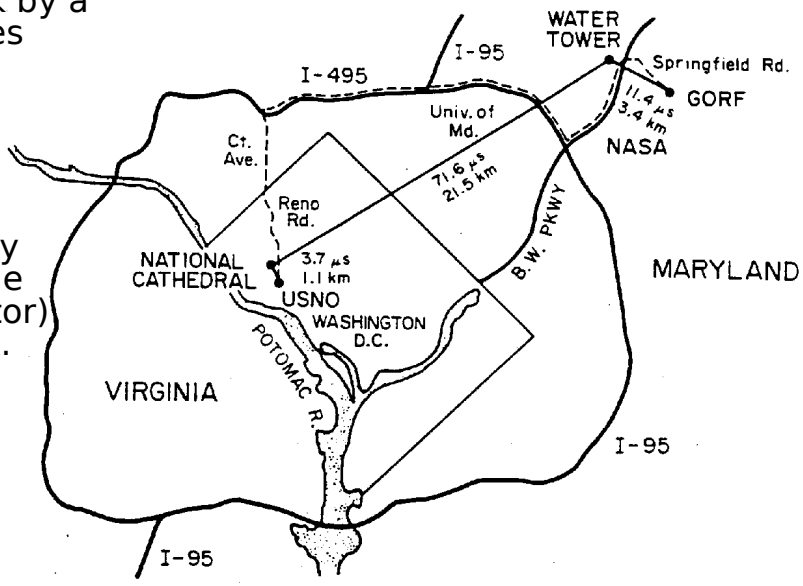
Thesis of Robert Nelson



- First Direct Comparison of the One-Way Speed of Light between the East-West and West-East Directions of the Rotating Earth

  - Pulses of laser light were sent from the Goddard Space Flight Center to the U. S. Naval Observatory utilizing a mirror on top of the Washington National Cathedral and sent back by a retro-reflector array. The sending and receiving times were recorded by a hydrogen maser atomic clock.

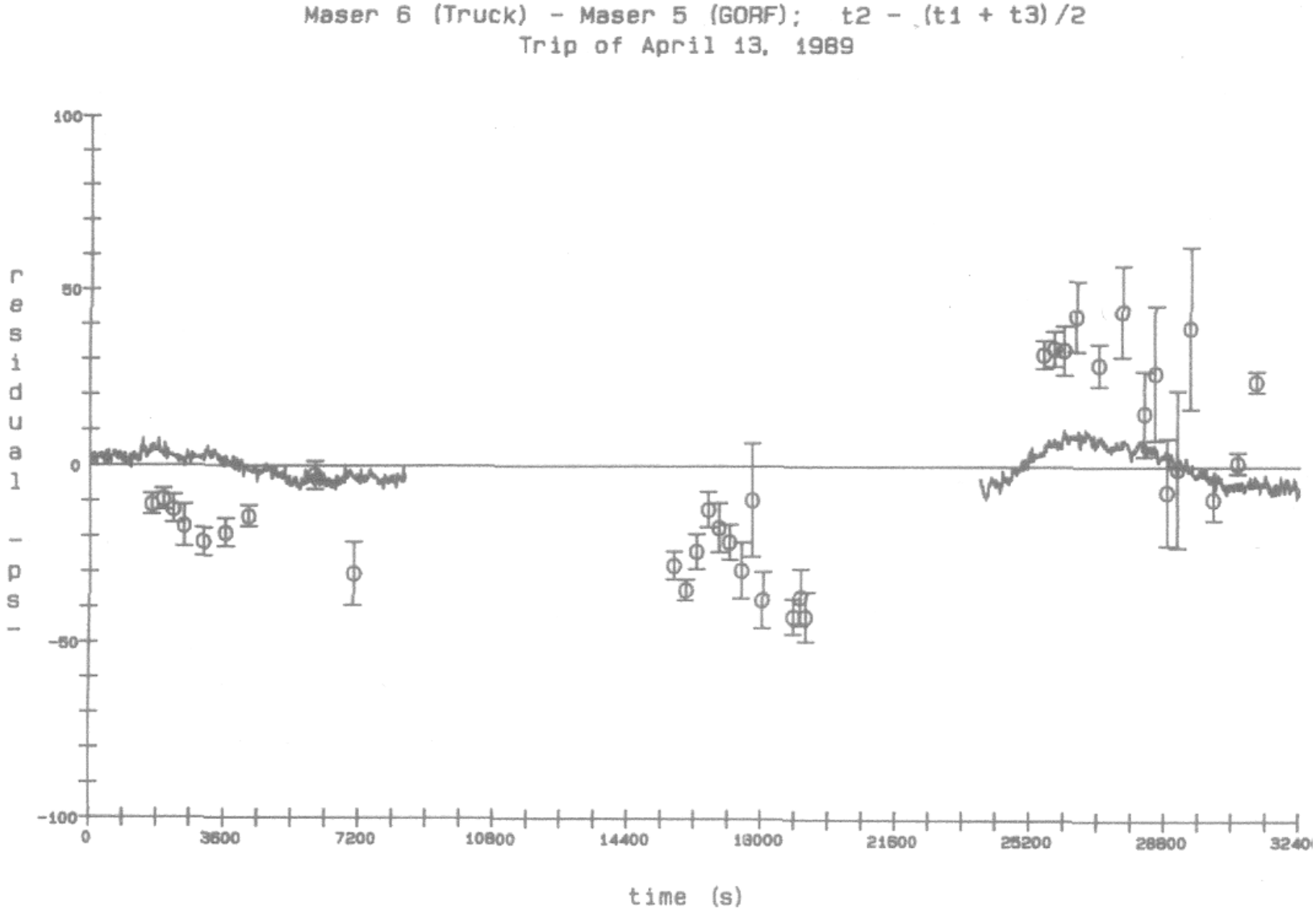
  - A second hydrogen maser atomic clock was carefully transported from the GSFC to the USNO and the time of arrival (and reflection by an adjacent retro-reflector) of the laser pulse recorded by the transported clock.



  - Nine repetitions showed the difference between the EW and WE transit times to be no greater than 100 ps, the limitation being systematic errors of unknown origin. Unfortunately this is the amount to be expected if the speed of light is affected by the surface speed of ~350 m/s.

  - The isotropy of the speed of light was not established by these experiments. It is hoped to redo them with higher precision and reduced systematic errors in the in the near future.

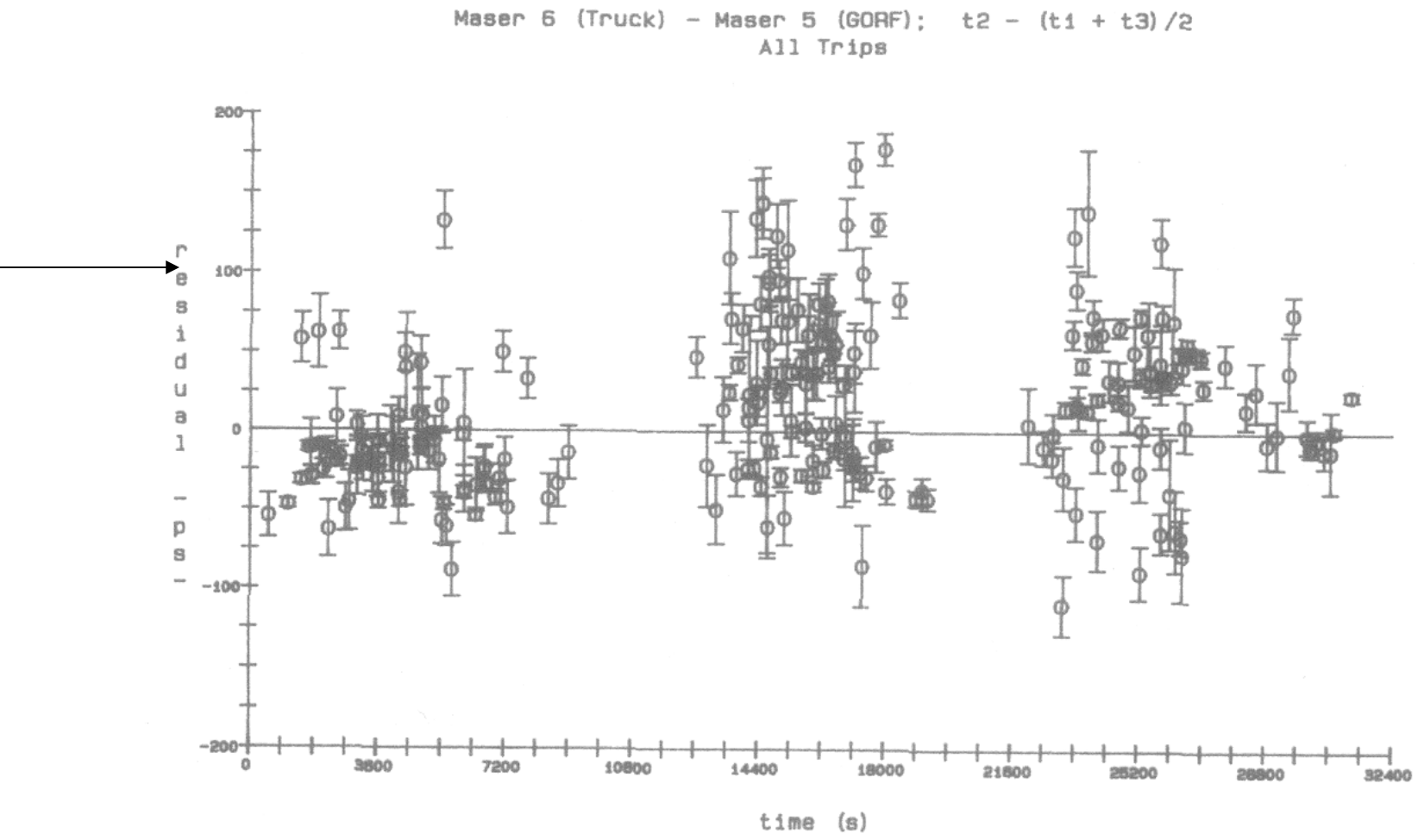
$$\Delta t = \frac{1}{2}[(t_2 - t_1) - (t_3 - t_2)] = t_2 - \frac{1}{2}(t_1 + t_3)$$



$If\ speed\ of\ light = r\omega \pm c, \quad \Delta t\ would\ be\ 80\ ps$

$If\ speed\ of\ light = \pm c, \quad \Delta t\ would\ be\ 0\ ps$

Experimental results were inconclusive



We hope to repeat this experiment during the coming year with the following improvements:

The air path for the laser light pulses will be replaced with dark optical fiber between the College Park and Baltimore County campuses of the University of Maryland (critical $\Delta t = 144$ ps)

Better timing electronics

Better environmental isolation during the transp;ort of the hydrogen maser atomic clocks

Definitive results are expected

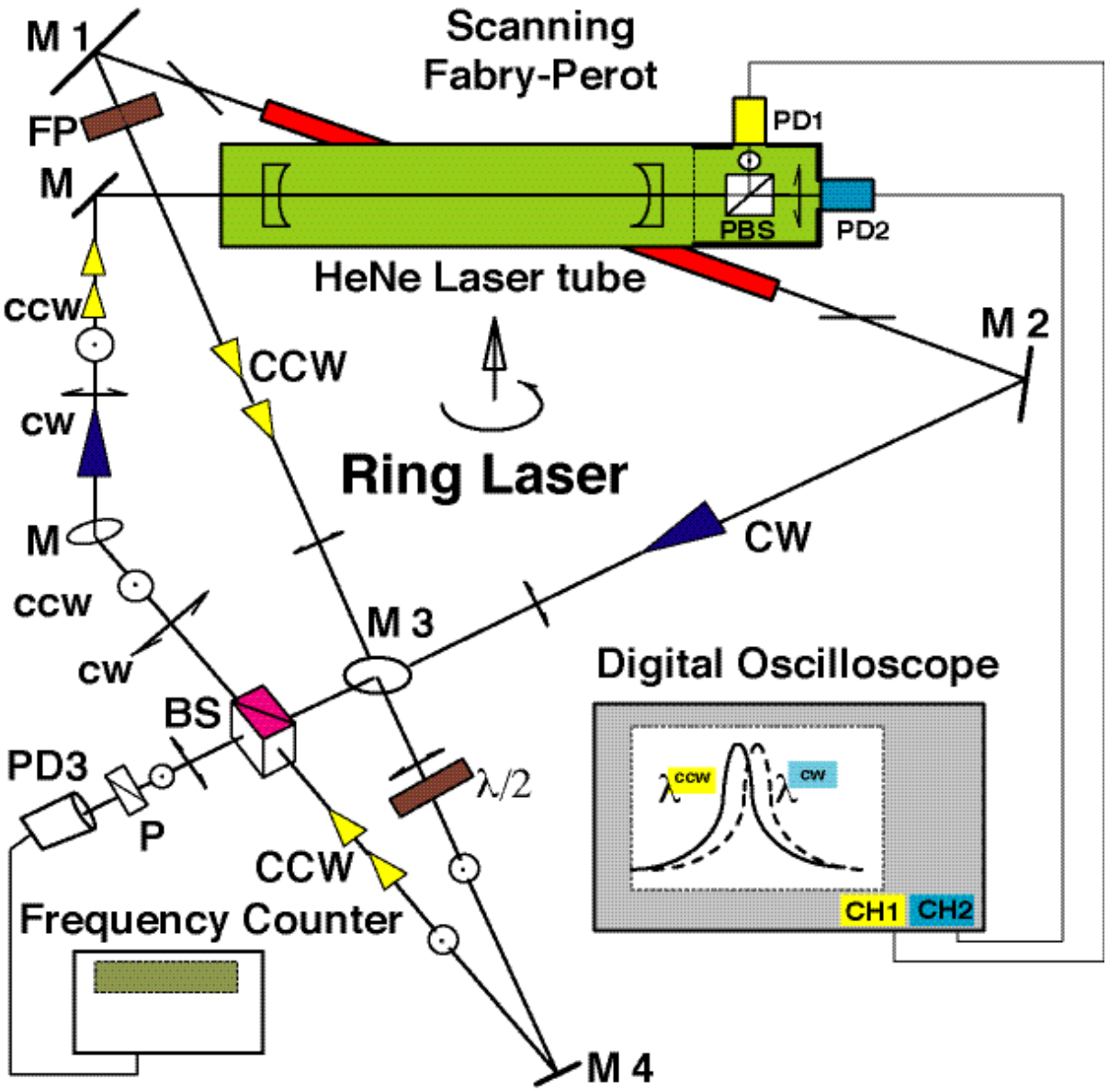
Light Propagation in a Rotating Reference System

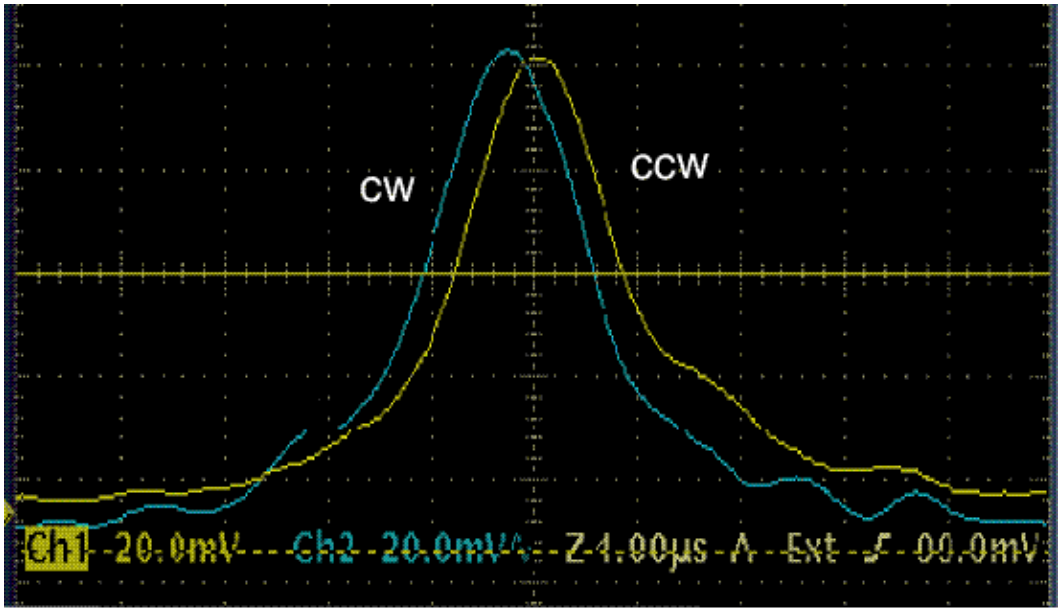
Heyi Zhang, Xuehua He And Yanhua Shih

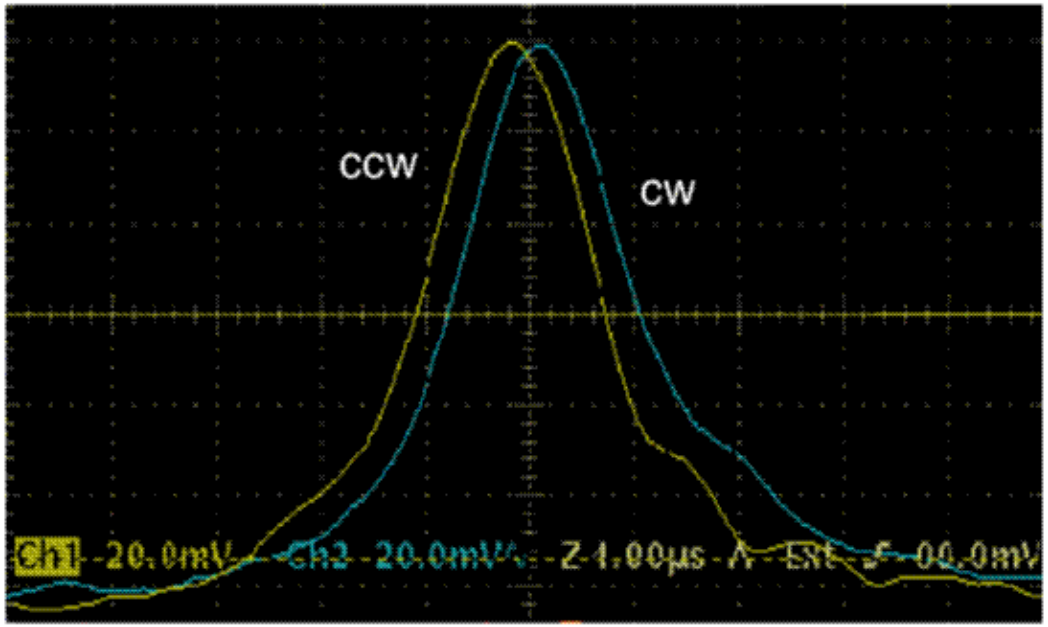
Department of Physics University of Maryland Baltimore County

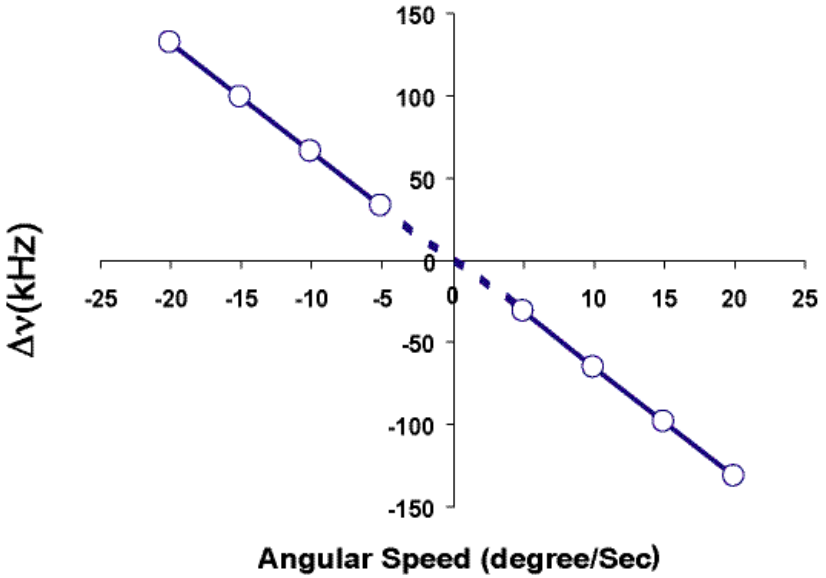
Unpublished work

(presented here with permission



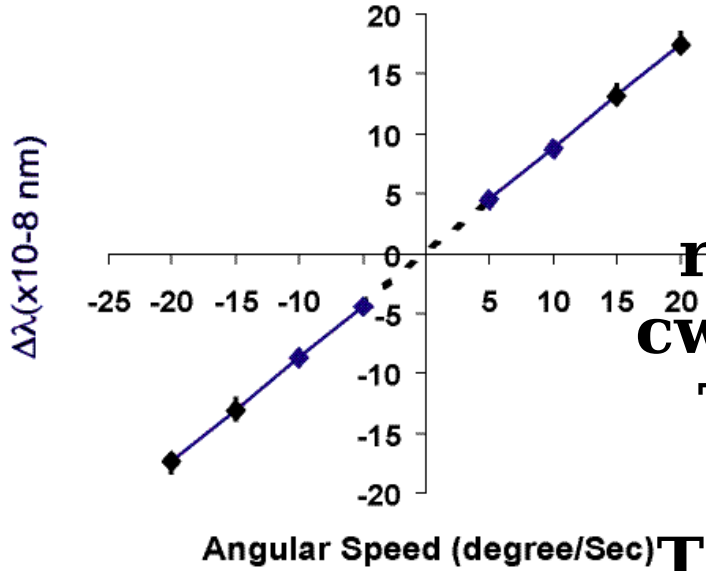

CW
CCW
Ch1 -20.0mV Ch2 -20.0mV Z 1.00µs A Ext


CCW
CW
Ch1 -20.0mV Ch2 -20.0mV Z 1.00µs A Ext



Increase in frequency is accompanied by decrease in wavelength

Decrease in frequency is accompanied by increase in wavelength



$$\lambda\nu = c$$

as locally measured on the rotating disk for each of the cw and ccw propagating waves. The locally measured phase velocity is ± c, not rω ± c. This agrees with the prediction of Yilmaz in 1969

Mathematical structure comparisons between General

Relativity and the Yilmaz Gauge Field Theory of gravity

A mathematical identity exists in Riemannian geometry,

the Freud identity, whose full implications are ignored in GR.

This has the following consequences:

Absence of interactions between massive bodies for solutions of the Einstein field equations

Replacement of the correct energy-momentum

Einstein's Introduction of Gravitational Field Stress-energy

Bianchi Identity:

$$D_\nu\left(\tfrac{1}{2}G_\mu{}^\nu\right)=\tfrac{1}{\sqrt{-g}}\,\partial_\nu\left(\sqrt{-g}\left(\tfrac{1}{2}G_\mu{}^\nu\right)\right)-\tfrac{1}{2}\left(\partial_\mu g_{\alpha\beta}\right)\left(\tfrac{1}{2}G^{\alpha\beta}\right)\equiv 0$$

"Obstreperous term"
(Schrödinger's name)

n transformed the obstreperous term into a plain diver

$$\tfrac{1}{2}\left(\partial_\mu g_{\alpha\beta}\right)\left(\tfrac{1}{2}G^{\alpha\beta}\right)=-\tfrac{1}{\sqrt{-g}}\,\partial_\nu\left(\sqrt{-g}u_\mu{}^\nu\right)$$

can then write, putting the matter tensor $T_\mu{}^\nu=\tfrac{1}{2}G_\mu{}^\nu$

$$D_\nu\left(\tfrac{1}{2}G_\mu{}^\nu\right)=\tfrac{1}{\sqrt{-g}}\,\partial_\nu\left(\sqrt{-g}\tau_\mu{}^\nu+\sqrt{-g}u_\mu{}^\nu\right)\equiv 0$$

equired by Gauss' Theorem for a conservation law.

918 Schrödinger evaluated the field stress-energy for
hwarzschild metric in rectangular coordinates and fou
every componentto be zero

$$u_{\mu}^{\ \nu} = 0$$

was very surprised and wrote a paper about it. Einste
lied that he was as surprised as Schrödinger, but that
n was that the Schwarzschild solution was only for one
All would be well with the two body solution.
No such solution ever found in GR until recently.
Two-disk solution, but there is no force between them
contrary to fact.)

n 1918, Bauer evaluated $u_{\mu}^{\ \nu}$ for the Minkowski metric
is no gravitational field. Using polar coordinaates he

$$u_{\mu}^{\ \nu} \neq 0$$

s a coordinate artifact, not a tensor. Einstein was seve
ed by the leading theorists and mathematicians for us

Freud Decomposition and Freud Identity (1939

eud identified a quantity

$$U_\mu{}^\nu = \frac{1}{2} G_\mu{}^\nu + u_\mu{}^\nu$$

ich satisfies the identity

$$\partial_\nu (\sqrt{-g} U_\mu{}^\nu) \equiv 0$$

arded the identity as a proof of Einstein's conservation

$$\partial_\nu (\sqrt{-g} \tau_\mu{}^\nu + \sqrt{-g} u_\mu{}^\nu) \equiv 0$$

wever the Freud identity is an independent indicial ide
nct from the Bianchi identity.

Structure of the Freud Quantity and the Indicial Nature of the Identity

$$\sqrt{-g}U_{\mu}^{\ \nu} = \partial_{\alpha} H_{\mu}^{\ \nu\alpha}$$

$$H_{\mu}^{\ \nu\alpha} = \begin{vmatrix} \delta_{\mu}^{\ \nu} & \delta_{\mu}^{\ \alpha} & \delta_{\mu}^{\ \sigma} \\ \sqrt{-g}g^{\nu\rho} & \sqrt{-g}g^{\alpha\rho} & \sqrt{-g}g^{\sigma\rho} \\ \Gamma^{\nu}_{\ \rho\sigma} & \Gamma^{\alpha}_{\ \rho\sigma} & \Gamma^{\sigma}_{\ \rho\sigma} \end{vmatrix} = -H_{\mu}^{\ \alpha\nu}$$

$$\partial_{\nu}(\sqrt{-g}U_{\mu}^{\ \nu}) = \partial_{\nu}\partial_{\alpha} H_{\mu}^{\ \nu\alpha} \equiv 0$$

Correct Way to Write the Freud Decomposition (Huseyin Yilmaz 1988)

Express the true tensor as the difference between the non-tensors.

Each non-tensor must therefore have a true tensor part added to the same non-tensor part which cancels

$$\frac{1}{2}G_\mu{}^\nu = U_\mu{}^\nu - u_\mu{}^\nu = (T_\mu{}^\nu + Z_\mu{}^\nu) - (t_\mu{}^\nu + Z_\mu{}^\nu)$$

$$= \tau_\mu{}^\nu + t_\mu{}^\nu .$$

general relativity the gravitational field stress energy suppressed from the field equatiions. Therefore

$$u_\mu{}^\nu = Z_\mu{}^\nu \quad \textbf{A non-tensor}$$

results of Schrodinger and Bauer are now understand

Non-tensor for the Standard Schwarzschild Me

$$ds^2 = \left(1-\frac{2M}{r}\right)dt^2 - \left(1-\frac{2M}{r}\right)^{-1} dr^2 - r^2(d\theta^2 + \sin^2\theta\, d\phi^2)$$

$$\sqrt{-g}z_\mu{}^\nu = \frac{1}{2}\begin{pmatrix} -\sin\theta & 0 & 0 & 0 \\ 0 & \sin\theta & 0 & 0 \\ 0 & -(M-r)\cos\theta & -\sin\theta & 0 \\ 0 & 0 & 0 & -\sin\theta \end{pmatrix}$$

density divergence vanishes identically (factor 1/2 d

$$\partial_\nu(\sqrt{-g}z_\mu{}^\nu) = \partial_r(\sqrt{-g}z_\theta{}^r) + \partial_\theta(\sqrt{-g}z_\theta{}^\theta) \quad (other\ terms = 0)$$

$$= \partial_r\left[-(M-r)\cos\theta\right] + \partial_\theta(-\sin\theta)$$

$$= \cos\theta - \cos\theta \equiv 0$$

Consequences of the Freud and Bianchi Identities

vanishing of the density divergence is a general prop

$$\partial_\nu(\sqrt{-g}z_\mu{}^\nu)=0$$

Freud: $\partial_\nu(\sqrt{-g}U_\mu{}^\nu)=\partial_\nu(\sqrt{-g}(\tau_\mu{}^\nu+z_\mu{}^\nu))=\partial_\nu(\sqrt{-g}\tau_\mu{}^\nu)\equiv 0$

Bianchi: $D_\nu(\frac{1}{2}G_\mu{}^\nu)=\frac{1}{\sqrt{-g}}\partial_\nu(\sqrt{-g}\tau_\mu{}^\nu)-\frac{1}{2}(\partial_\mu g_{\alpha\beta})\tau^{\alpha\beta}$

$$+\frac{1}{\sqrt{-g}}\partial_\nu(\sqrt{-g}t_\mu{}^\nu)-\frac{1}{2}(\partial_\mu g_{\alpha\beta})t^{\alpha\beta}\equiv 0$$

first term on the right vanishes by the Freud identity.

uping terms,

$$-\frac{1}{2}(\partial_\mu g_{\alpha\beta})(\tau^{\alpha\beta}+t^{\alpha\beta})+\frac{1}{\sqrt{-g}}\partial_\nu(\sqrt{-g}t_\mu{}^\nu)\equiv 0.$$

Therefore, $\boxed{\frac{1}{2}(\partial_\mu g_{\alpha\beta})\tau^{\alpha\beta}\equiv 0}$ $if\ t_\mu{}^\nu=0$ as in GR.

The Equations of Motion

$$\frac{dp_\mu}{d\tau} = \frac{1}{2}\partial_\mu g_{\alpha\beta}(\tau^{\alpha\beta} + t^{\alpha\beta}) \equiv \frac{1}{\sqrt{-g}}\partial_\nu(\sqrt{-g}\, t_\mu{}^\nu)$$

The interaction is carried by the gravitational field stress energy tensor!

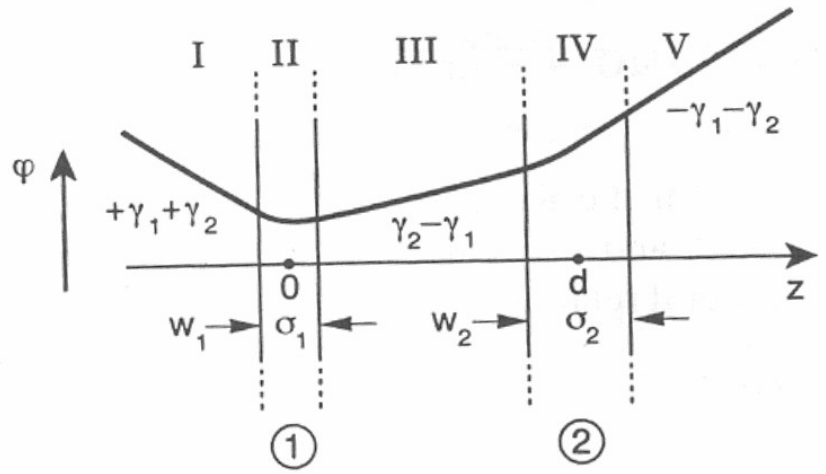
analogous to electrodynamics where the Lorentz force vergence of the Faraday/Maxwell electromagnetic field stress energy tensor

he absence of $t_{,\mu}^{\ \nu}$ as is the case for general relativity, there is no interaction

t two-disk solutions have been found which show expli absence of interaction (Alley, Burrows and Yilmaz 199 xact solutions of GR must exhibit DIVISORS OF ZERO

$$\boxed{\frac{1}{2}(\partial_\mu g_{\alpha\beta})\tau^{\alpha\beta} \equiv 0}$$

Exact Two-disk Solution



$$\varphi_I = -\frac{\sigma_1 w_1}{2} z - \frac{\sigma_2 w_2}{2} (z-d)$$

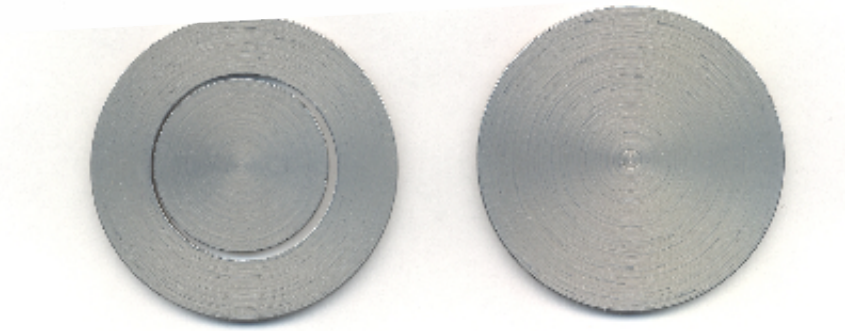
$$\varphi_{II} = \frac{\sigma_1}{2} z^2 - \frac{\sigma_2 w_2}{2} (z-d) + \sigma_1 w_1^2/8$$

$$\varphi_{III} = \frac{\sigma_1 w_1}{2} z - \frac{\sigma_2 w_2}{2} (z-d)$$

$$\varphi_{IV} = \frac{\sigma_2}{2} (z-d)^2 + \frac{\sigma_1 w_1}{2} z + \sigma_2 w_2^2/8$$

$$\varphi_V = \frac{\sigma_1 w_1}{2} z + \frac{\sigma_2 w_2}{2} (z-d)$$

FIGURE 1. Two slabs, neglecting edge effects.



One-dimensional problem: two thin disks and a guard ring to suppress edge effects (like a parallel plate capacitor). The potential is a function only of the coordinate z.

etric Solution for the One-dimensional Proble

$$ds^2 = e^{-2\varphi}dt^2 - e^{2\varphi(1+\varepsilon)}(dx^2 + dy^2) - e^{2\varphi(1+2\varepsilon)}dz^2$$

$$\tfrac{1}{2}G_\mu{}^\nu = \begin{pmatrix} 1+\varepsilon & 0 & 0 & 0 \\ 0 & \varepsilon/2 & 0 & 0 \\ 0 & 0 & \varepsilon/2 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix} \nabla^2\varphi + (1-\varepsilon^2)t_\mu{}^\nu \quad = \tau_\mu{}^\nu + (1-\varepsilon^2)t_\mu{}^\nu$$

$$Einstein: \varepsilon^2 = 1 \qquad Yilmaz: \varepsilon^2 = 0$$

$$\tau^{\alpha\beta} = g^{\alpha\mu}\tau_\mu{}^\beta = \begin{pmatrix} e^{2\varphi}(1+\varepsilon) & & & \\ & -e^{-2\varphi(1+\varepsilon)}\frac{\varepsilon}{2} & & \\ & & -e^{-2\varphi(1+\varepsilon)}\frac{\varepsilon}{2} & \\ & & & 0 \end{pmatrix} \nabla^2\varphi \neq 0$$

$$\tfrac{1}{2}\partial_\mu g_{\alpha\beta} = \begin{pmatrix} -e^{-2\varphi} & & & \\ & -e^{2\varphi(1+\varepsilon)}(1+\varepsilon) & & \\ & & -e^{2\varphi(1+\varepsilon)}(1+\varepsilon) & \\ & & & -e^{2\varphi(1+2\varepsilon)}(1+2\varepsilon) \end{pmatrix} \partial_z\varphi \neq 0$$

$$\tau^{\alpha\beta} = \begin{pmatrix} e^{2\varphi}(1+\varepsilon) & & & \\ & -e^{-2\varphi(1+\varepsilon)}\,\frac{\varepsilon}{2} & & \\ & & -e^{-2\varphi(1+\varepsilon)}\,\frac{\varepsilon}{2} & \\ & & & 0 \end{pmatrix} \nabla^2\varphi \neq 0$$

$$\tfrac{1}{2}\partial_\mu g_{\alpha\beta}\,\tau^{\alpha\beta} = -(1+\varepsilon) + 2(1+\varepsilon)\frac{\varepsilon}{2} = -(1-\varepsilon^2)\nabla^2\varphi\,\partial_z\varphi = 0 \;\; for \;\; \varepsilon^2 = 1$$

ese exact two body solutions (ε = 1 and ε = -1) for the Einstein fi
equation exhibit divisors of zero so that the right hand side
of the geodesic equations of motion vanishes!
This is a property of all solutions of the Einstein field equations.
It is a consequence of the Bianchi and Freud identities.

ark about the Energy-momentum Conservation

$$\partial_\nu(\sqrt{-g}\tau_\mu{}^\nu)\equiv 0$$

This is expressed by the Freud Identity:

$$\partial_\nu(\sqrt{-g}U_\mu{}^\nu)=\partial_\nu(\sqrt{-g}(\tau_\mu{}^\nu+z_\mu{}^\nu))=\partial_\nu(\sqrt{-g}\tau_\mu{}^\nu)\equiv 0$$

Freud quantity is equivalent to the gauge d'Alemberti
for the gauge field of the Yilmaz theory

$$U_\mu{}^\nu = W^2\varphi_\mu{}^\nu - \frac{1}{\sqrt{-g}}\partial_\alpha(\sqrt{-g}g^{\rho\nu}\partial_\rho\varphi_\mu{}^\alpha)$$

hen one considers the diferential form of the relation

$$g_{\mu\nu}=(\eta e^{2(\hat{\varphi 1}-2\hat{\varphi})})_{\mu\nu}$$

General Relativity derives the Geodesic Equations fro
eld Equations by violating energy-momentum conserva

$$\frac{1}{2}G_{\mu}^{\ \nu} = \tau_{\mu}^{\ \nu} = \sigma u_{\mu} u^{\nu}$$

$$D_{\nu}(\sigma u_{\mu} u^{\nu}) = \frac{1}{\sqrt{-g}}\partial_{\nu}(\sqrt{-g}\sigma u_{\mu} u^{\nu}) - \frac{1}{2}(\partial_{\mu} g_{\alpha\beta})(\sigma u^{\alpha} u^{\beta}) \equiv 0$$

$$\frac{1}{\sqrt{-g}}\partial_{\nu}(\sqrt{-g}\sigma u_{\mu} u^{\nu}) = \frac{1}{\sqrt{-g}}\partial_{\nu}(\sqrt{-g}\sigma u^{\nu}) u_{\mu} + \sigma u^{\nu}\partial_{\nu} u_{\mu}$$

$$Put \quad \partial_{\nu}(\sqrt{-g}\sigma u^{\nu}) = 0 \quad Conservation\ of\ rest\ mass!$$

$$Wrong! \quad Energy-momentum\ \sqrt{-g}\sigma u_{\mu} u^{\nu}\ is\ conserved!$$

$$\sigma u^{\nu}\partial_{\nu} u_{\mu} = \sigma \frac{\partial x^{\nu}}{\partial \tau}\frac{\partial}{\partial x^{\nu}} u_{\mu} = \sigma \frac{du_{\mu}}{d\tau}$$

$$\sigma \frac{du_{\mu}}{d\tau} = \frac{1}{2}(\partial_{\mu} g_{\alpha\beta})(\sigma u^{\alpha} u^{\beta}) \quad Geodesic\ Equations$$

uniqueness of the General Relativity Central Body Me

$$ds^2 = \left(1+\frac{2\varepsilon M}{r}\right)^{-\frac{1}{\varepsilon}} - \left(1+\frac{2\varepsilon M}{r}\right)^{\frac{1}{\varepsilon}} dr^2 - \left(1+\frac{2\varepsilon M}{r}\right)^{1+\frac{1}{\varepsilon}} r^2(d\theta^2 + \sin^2\theta d\phi^2)$$

$$ds^2 = \left(1-\frac{2M}{r}\right) dt^2 - \left(1-\frac{2M}{r}\right)^{-1} dr^2 - r^2(d\theta^2 + \sin^2\theta d\phi^2) \qquad (\varepsilon = -1)$$

$$ds^2 = \left(1+\frac{2M}{r}\right)^{-1}\left(1+\frac{2M}{r}\right) dr^2 - \left(1+\frac{2M}{r}\right)^2 r^2(d\theta^2 + \sin^2\theta d\phi^2) \quad (\varepsilon = +1)$$

$$ds^2 = e^{-\frac{2M}{r}} dt^2 - e^{+\frac{2M}{r}}(r^2 d\theta^2 + r^2 \sin^2\theta d\phi^2 + dr^2) \qquad (\varepsilon = 0)$$

ε = -1 Schwarzschild

ε = +1 Droste (r→ r - 2M) No Event Horizon

ε = 0 Yilmaz

tein-Hilbert Curvature Tensor for the Central Body Me
(M/r = ϕ)

$$\begin{array}{c} \\ \frac{1}{2}G_\mu{}^\nu = \end{array} \begin{array}{c} \begin{array}{cccc} t & r & \theta & \phi \end{array} \\ \begin{pmatrix} 1+\varepsilon & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & \varepsilon/2 & 0 \\ 0 & 0 & 0 & \varepsilon/2 \end{pmatrix} \end{array} \nabla^2\varphi + (1-\varepsilon^2)t_\mu{}^\nu = \tau_\mu{}^\nu + (1-\varepsilon^2)t_\mu{}^\nu$$

= -1 Schwarzschild

ε = +1 Droste

ε = 0 Yilmaz

$$\frac{1}{2}G_0{}^0 = 0$$

Unphysical

$$\frac{1}{2}G_0{}^0 = 2\nabla^2\varphi$$

Unphysical

$$\frac{1}{2}G_0{}^0 = \nabla^2\varphi + t_0{}^0$$

$$= \tau_0{}^0 - \frac{1}{2}(\nabla\phi)^2$$

Correct Newtonian Correspondence to

The Yilmaz theory completes Einstein's theory, achieving Einstein's wishes with exact solutions

for important physical systems.

The gravitational field stress-energy is a true tensor.

The successes of General Relativity use approximations to the Yilmaz theory.

There should be explicit recognition of this

paradigm shift to the new theory!